APPLICATION FOR INCIDENTAL HARASSMENT AUTHORIZATION FOR 2016 ANCHOR RETRIEVAL PROGRAM CHUKCHI AND BEAUFORT SEAS ALASKA

Prepared for

Fairweather LLC

301 Calista Court

Anchorage, Alaska 99518

Prepared by

Fairweather Science LLC

301 Calista Court

Anchorage, Alaska 99518

February 2016

Revised April 2016

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ACRONYMS AND ABBREVIATIONS

ABWC	Alaska Beluga Whale Committee
ADFG	Alaska Department of Fish and Game
AEWC	Alaska Eskimo Whaling Commission
AHD	Acoustic Harassment Devices
AHTS	Anchor Handling Towing Vessels
ASAMM	Aerial Surveys of Arctic Marine Mammals
BOEM	Bureau of Ocean and Energy Management
CAA	Conflict Avoidance Agreement
CFR	Code of Federal Regulations
CF	Correction Factor
CHAOZ	Chukchi Acoustic, Oceanographic, and Zooplankton
CI	Confidence Interval
COMIDA	Chukchi Sea Offshore Monitoring in Drilling Area
Com Center	North Slope Communications Centers
CSESP	Chukchi Sea Environmental Studies Program
CV	Coefficient of Variation
dB re 1 μPa	decibels referenced to one microPascal
DP	Dynamic Positioning
DPS	Distinct Population Segment
ECO	Edison Chouest Offshore
EEZ	Exclusive Economic Zone
EIS	Environmental Impact Statement
ESA	Endangered Species Act
EZ	Exclusion Zone
ft	feet
ft^2	square feet
FWS	Fairweather Science LLC
FWX	Fairweather, LLC
Fairweather	Fairweather LLC and Fairweather Science LLC collectively
GPS	Global Positioning System
Hz	Hertz
IHA	Incidental Harassment Authorizations
IUCN	International Union for Conservation of Nature
kHz	Kilohertz
km	Kilometers
km^2	Square Kilometers
KSOP	Kuukpik Subsistence Oversight Panel
LBCHU	Ledyard Bay Critical Habitat Unit
LOA	Letter of Authorization
m	meters
m^2	square meters
MMPA	Marine Mammal Protection Act

4MP	Marine Mammal Monitoring and Mitigation Plan
MMS	Minerals Management Service
mi	Miles
mi^2	Square Miles
min	minutes
MODIS	Moderate Resolution Imaging Spectroradiometer
MODU	Mobile offshore drilling unit
NMFS	National Marine Fisheries Service
NMIN	Minimum Population Estimate
NMML	National Marine Mammal Laboratory
NOAA	National Oceanic and Atmospheric Administration
NSB	North Slope Borough
NSSI	North Slope Science Initiative
OCS	Outer Continental Shelf
OSRV	Oil spill response vessel
OST	Oil Spill Toolkit
PBR	Potential Biologic Removal
POC	Plan of Cooperation
PSO	Protected Species Observer
PTS	Permanent Threshold Shift
rms	root-mean-square
ROV	Remotely-Operated Underwater Vehicle
SEL	Sound Exposure Level
Shell	Shell Exploration & Production Company
SPL	Sound Pressure Level
SPLASH	Structure of Populations, Levels of Abundance, and Status of Humpbacks
SSC	Sound Source Characterization
SSV	Sound Source Verification
TS	Threshold Shift
TTS	Temporary Threshold Shift
U.S.	United States
USC	United States Coast Guard
USFWS	United States Fish and Wildlife Service

INTRODUCTION

The National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) administer regulations governing the issuance of Incidental Harassment Authorizations (IHAs) and Letters of Authorization (LOAs) permitting the incidental, but not intentional, take of marine mammals under certain circumstances. The regulations are codified in 50 Code of Federal Regulations (CFR) Part 216, Subpart I (Sections 216.101-216.108). The Marine Mammal Protection Act (MMPA) defines ‘take’ to mean “to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal” (16 United States Code [USC] Chapter 31, Section 1362 (13)). Section 216.104 sets out 14 specific items that must be addressed in requests for rulemaking and renewal of regulations pursuant to Section 101(a)(5) of the MMPA. The 14 items are addressed in Sections 1 through 14 of this application.

Fairweather LLC (FWX) or Fairweather Science, LLC (FWS) if individually or collectively (Fairweather) plan to retrieve large seafloor anchors and associated gear that were deployed as part of Shell Exploration and Production Company’s (Shell) exploratory drilling program at five locations in Kotzebue Sound, Chukchi Sea, and Beaufort Sea during the 2016 open water season (early July through October). FWS requests an IHA pursuant to Section 101(a)(5)(D) of the MMPA, 16 USC § 1371 (a)(5) to allow non-lethal takes of whales and seals incidental to the 2016 anchor retrieval program.

The aspects of the retrieval program that have the potential to incidentally harass marine mammals are the underwater noise associated with vessels actively handling the anchors (due to use of thrusters to maintain position and unseat the anchors), the potential use of a side scan sonar to obtain high resolution imagery of the site before and after the retrieval operations, and the very unlikely event of ice management near Point Barrow. All activities will take place during the open water season and will avoid subsistence whale harvest activities. The activities at each of the anchor array sites will take place over a two to seven-day period, so all potential impacts will be temporary and localized. Through this application, we will analyze anticipated impacts from underwater sounds to marine mammals expected in the project area.

1.0 DESCRIPTION OF ACTIVITIES

A detailed description of the specific activity or class of activities that can be expected to result in incidental taking of marine mammals.

1.1 PROJECT PURPOSE

As part of Shell's exploratory drilling program in 2012 and 2015, large anchors were deployed at five locations: 1) Good Hope Bay in Kotzebue Sound for barge moorings, 2) Burger A site in the Chukchi Sea for the arctic containment system moorings, 3) Burger V site in the Chukchi Sea for the M/V *Noble Discoverer* (Discoverer) drilling rig moorings, 4) Kakapo in the Chukchi Sea for a contingency location for the Discoverer drilling rig, and 5) Sivulliq site in the Beaufort Seas for the mobile offshore drilling unit (MODU) *Kulluk* (Kulluk) drilling rig moorings (Figure 1). The mooring systems at each site include anchors, chain, wire rope, clump weights, connecting gear, and float ropes. The anchors and all associated gear are scheduled for retrieval. The retrieval program will be funded by Shell but all aspects of the program will be operated by FWX or FWS individually or collectively (Fairweather).

1.2 DESCRIPTION OF MOORINGS

The deployed location of each mooring is provided in Table 1 and Table 2. Each mooring site is configured differently based on the purpose of the mooring. These mooring systems are designed to hold drilling rigs or large barges in place by connecting the mooring line to the marine asset to anchor it to the seafloor. A mooring system consists of a mooring line that will include a combination of chain, wire rope, and synthetic fiber rope; connectors (shackles, links, swivels, etc.); and an anchoring point (drag anchor, clump weight, etc.). When Shell departed the Chukchi and Beaufort Seas, these mooring systems were left in place at the five locations shown in Figure 1. The arrays vary in size and configuration and will be retrieved with the use of three specialized Anchor Handling Towing Supply Vessels (AHTSV) and the oil spill response vessel (OSRV) *Nanuq* during the open water season of 2016.

1.3 DESCRIPTION OF VESSELS

These specialized AHTSVs are designed specifically to handle large mooring systems. They have large winches for towing and anchor handling, large deck space to allow for storage of anchors and chain, lockers for chain, and have more power to increase the pull. The fleet of vessels includes four vessels: M/V *Aiviq*, M/V *Ross Chouest*, M/V *Nanuq*, and M/V *Dino Chouest*. All but the *Dino Chouest* have previously worked in the Arctic as part of Shell's exploration program. One of the AHTSVs (*Dino Chouest*) will carry a Remotely Operated Underwater Vehicle (ROV) specifically designed to manipulate float ropes. A description of each of the AHTSV is provided in Table 3. Photos of the vessels are provided in Figure 2.

Figure 1. 2016 Anchor Retrieval Locations.

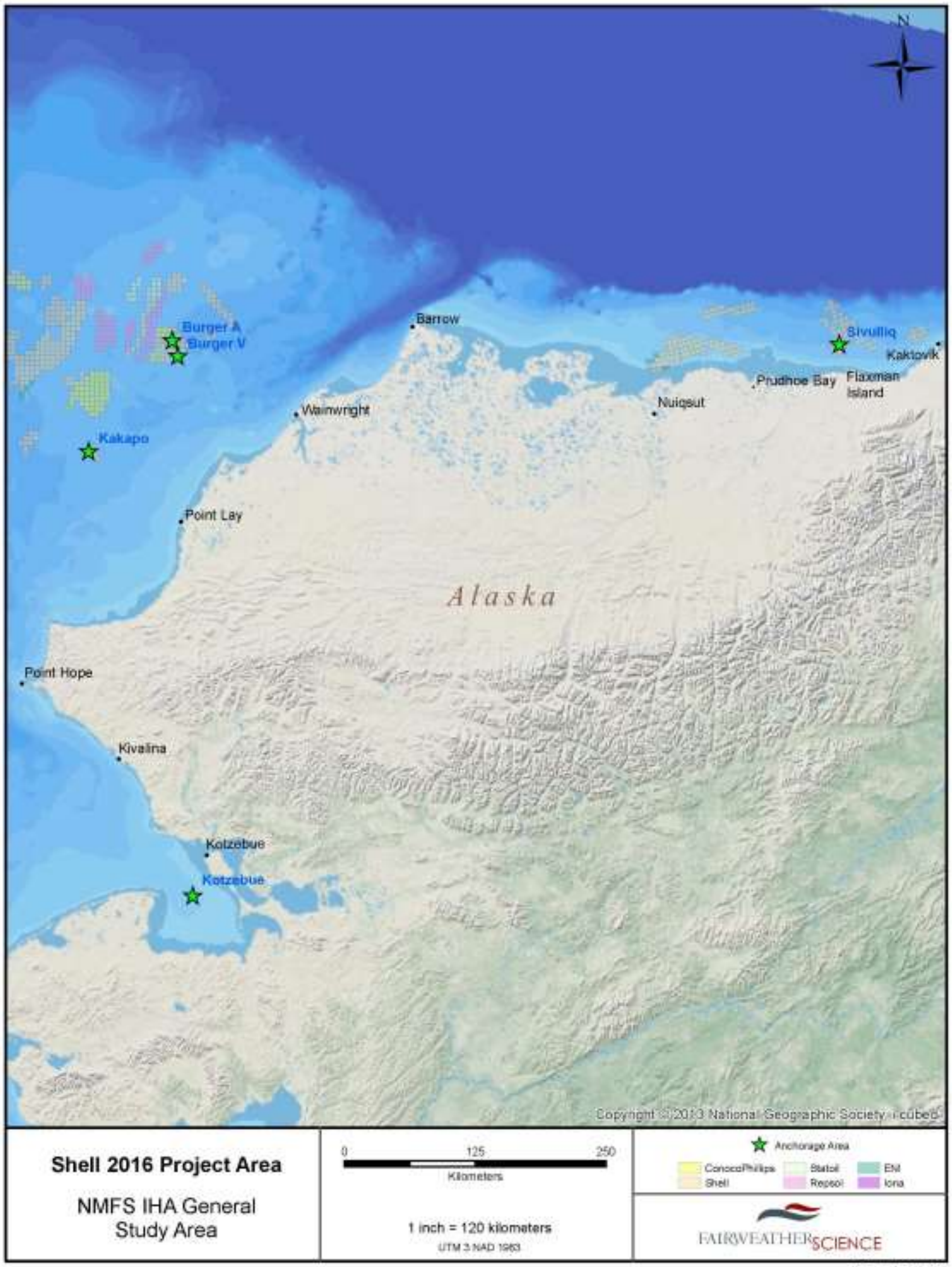


Table 1. Deployed Locations of Anchors to be Retrieved in Chukchi Sea.

Anchor Location	Anchor Identifier	Approximate Distance from Shore (km)	Latitude	Longitude	Approximate Water Depth (m)
Burger V	Anc 1 483	106	71°10'35.1728"N	163°02'41.4813"W	44-46*
	Anc 2 484	105	71°10'11.3584"N	163°03'04.8592"W	
	Anc 3 485	105	71°10'01.1419"N	163°04'15.4532"W	
	Anc 4 486	106	71°10'09.2762"N	163°05'27.6326"W	
	Anc 5 487	107	71°10'31.6146"N	163°05'58.6524"W	
	Anc 6 488	107	71°10'54.8554"N	163°05'35.4827"W	
	Anc 7 481	107	71°11'05.6502"N	163°04'26.8913"W	
	Anc 8 482	107	71°10'57.8196"N	163°03'13.4298"W	
Burger A	Anc 1 450	121	71°18'4.983"N	163°12'45.783"W	45-46*
	Anc 1 456	121	71°18'6.454"N	163°12'55.528"W	
	Anc 1 457	121	71°18'6.380"N	163°12'49.991"W	
	Anc 2 451	122	71°18'16.254"N	163°12'54.710"W	
	Anc 2 452	121	71°18'16.227"N	163°12'49.538"W	
	Anc 2 453	121	71°18'16.166"N	163°12'44.659"W	
	Anc 3 454	121	71°18'11.271"N	163°12'44.726"W	
	Anc 4 455	122	71°18'21.129"N	163°12'44.738"W	
	Anc 5A 500	122	71°18'35.567"N	163°12'47.205"W	
	Anc 5B 501	122	71°18'35.641"N	163°12'49.951"W	
	Anc 6A 600	122	71°18'40.199"N	163°12'46.907"W	
	Anc 6B 601	122	71°18'40.254"N	163°12'49.613"W	
	Anc 7A 700	122	71°18'44.912"N	163°12'46.451"W	
Burger A continued	Anc 7B 701	123	71°19'5.187"N	163°12'47.313"W	
	Anc 8A 800	122	71°18'49.510"N	163°12'46.400"W	
	Anc 8B 801	122	71°18'49.534"N	163°12'48.728"W	
	Anc 9A 509	122	71°18'25.691"N	163°12'11.643"W	
	Anc 9B 609	122	71°18'25.805"N	163°12'26.537"W	
	Anc 9C 709	122	71°18'25.975"N	163°12'41.797"W	
Kakapo	Anc 1-A	112	70°21'40.214"N	165°21'45.610"W	41***
	Anc 1-B	112	70°21'35.151"N	165°21'52.016"W	
	Anc 2-A	112	70°20'21.539"N	165°23'20.486"W	
	Anc 2-B	111	70°20'26.574"N	165°23'14.406"W	

*2015 Shell Exploration and Production Plan
**NOAA Bathymetry GIS Data Layer
***2012 Shell Exploration and Production Plan

Table 2. Deployed Locations of Anchors to be Retrieved at Kotzebue and Sivulliq.

Anchor Location	Anchor Identifier	Approximate Distance from Shore (km)	Latitude	Longitude	Approximate Water Depth (m)
Kotzebue	1A	16	66°13'44.1810"N	163°28'04.9601"W	9**
	1B	16	66°13'35.9570"N	163°27'59.7073"W	
	1C	16	66°13'38.3014"N	163°28'20.2109"W	
	2A	15	66°13'03.9549"N	163°27'55.8054"W	
	2B	14	66°12'55.6454"N	163°27'50.8322"W	
	2C	15	66°12'57.9844"N	163°28'11.4364"W	
	3A	15	66°13'06.9030"N	163°26'14.8413"W	
	3B	15	66°12'58.6139"N	163°26'09.9079"W	
	3C	15	66°13'01.0604"N	163°26'30.2909"W	
	4A	16	66°13 46.9549"N	163°26'28.1640"W	
	4B	16	66°13 38.6508"N	163°26'23.0360"W	
	4C	16	66°13'41.0499"N	163°26'43.4201"W	
Sivulliq	Anc 1 461	26	70°23'57.443"N	145°59'38.545"W	33-34***
	Anc 2 462	26	70°24'1.508"N	145°58'50.460"W	
	Anc 3 463	26	70°23'57.041"N	145°58'3.277"W	
	Anc 4 464	26	70°23'45.205"N	145°57'29.494"W	
	Anc 5 465	25	70°23'28.981"N	145°57'17.363"W	
	Anc 6 466	25	70°23'13.171"N	145°57'30.348"W	
	Anc 7 467	25	70°23'1.787"N	145°58'5.961"W	
	Anc 8 468	24	70°22'57.622"N	145°58'54.268"W	
	Anc 10 470	25	70°23'14.028"N	146°0'15.400"W	
	Anc 11 471	26	70°23'30.160"N	146°0'28.398"W	
	Anc 12 472	26	70°23'45.977"N	146°0'13.995"W	

*2015 Shell Exploration and Production Plan
**NOAA Bathymetry GIS Data Layer
***2012 Shell Exploration and Production Plan

Figure 2. Photos of AHTSVs to be Used During Anchor Handling Program.

Table 3. Anchor Retrieval Proposed Vessels.

Vessel Name	Specification	Length	Width	Draft	Maximum Speed	Available Fuel Storage
M/V *Aiviq*	Anchor handling Ice Classed* Refueling Support	360 feet	80 feet	28 feet	15 knots	527,073 gallons
M/V *Ross Chouest*	Anchor handling	256 feet	54 feet	18 feet	12 knots	149,157 gallons
M/V *Nanuq*	Anchor handling Ice Classed* Refueling Support	301 feet	60 feet	21 feet	15 knots	323,065 gallons
M/V *Dino Chouest*	Anchor handling ROV	348 feet	72 feet	24.9 feet	15 knots	508,337 gallons

*As discussed below, minimal ice management may occur. To the extent necessary, operated vessels may contact small ice floes (that do not have marine mammals visibly on them) in order to maximize survey efficiency. In other words, these vessels (M/V *Aiviq* and M/V *Nanuq*) do not need to avoid ice for safety reasons.

1.4 DESCRIPTION OF RETRIEVAL PROGRAM

The goal of the retrieval program will be to complete operations efficiently and safely within one season, taking into consideration ice, weather, and subsistence harvest activities. Preliminary calculations indicate the vessels will have sufficient fuel onboard to have endurance to remain offshore with minimal fuel transfers at sea. The number of crew changes and vessel resupply will depend on the progress of the retrieval program, but, if necessary, will take place in Kotzebue, Wainwright, or Prudhoe Bay. Through the Olgoonik Fairweather, LLC joint venture, FWS has provided crew change and logistic support for multiple vessels in all three locations since 2008. A small, flat-bottom crew change vessel is available at each location to transfer personnel, equipment, and groceries from shore to the AHTSV. Helicopters will not be used in this program, unless in an emergency situation. FWS will work closely with communities at each potential crew change location to avoid conflict with any subsistence activities, as we have successfully accomplished since 2008.

Vessels will mobilize from Dutch Harbor in late June to arrive in Kotzebue area by early July. Delmar (the owners of some of the mooring systems and onboard anchor handling technicians) and FWX have developed multiple scenarios to retrieve all of the systems within one season. Each AHTSV vessel is a different size and each will hold different amounts of equipment depending on deck space, storage reel space, chain locker space, storage location, and equipment type to meet stability requirements. Timing and movement of the four vessels is a complex planning exercise. It is likely that one or two vessels will need to transit to Dutch Harbor to offload anchors will be required. The goal will be to arrive at Kotzebue Sound and retrieve these systems in early July. FWS will work closely with the communities (Kotzebue, Kivalina, and Shishmaref) to ensure there are no conflicts with the beluga whale harvest. If subsistence harvest activities are taking place, we will not retrieve anchors until cleared (by the communities) to do so. The vessels will move into the Chukchi Sea to retrieve the Burger and Kakapo anchors, depending on ice presence. As soon as the passage to Barrow around Point Barrow is ice free and safe for passage to the Beaufort Sea, two of the four vessels will immediately transit to the Sivulliq site. Typically, this occurs in late July/early August. Retrieval operations will be completed and vessels out of the Beaufort prior to the August 25th commencement for the Nuiqsut/Kaktovik bowhead whale harvest. Once the Sivulliq anchors are retrieved, the two vessels will return to the Chukchi Sea to complete any remaining operations. Figure 3 shows one example scenario developed by Delmar and FWX for the timing of the program.

Figure 3. Example Activity Plan for 4 AHTSV Anchor Retrieval Program.

Activity Plan (4 Vessels)

Activity Plan (4 Vessels) DRAFT

	#	Activity Plan	Start	Finish	Duration
43		OPERATIONS PHASE	07/20/16	08/25/16	37d
44	1	Alviq - Transits to Burger	07/20/16	07/25/16	6d
45	2	Dino - Transit to Burger	07/20/16	07/25/16	6d
46	3	Ross - Transit Dutch to Kotzebue	07/21/16	07/26/16	6d
47	4	Nanuq - Transit Dutch to Kotzebue	07/21/16	07/26/16	6d
48	5	Alviq - Recover Burger V #1 - #4	07/26/16	07/27/16	2d
49	6	Dino - Recover Burger V #5 - #8	07/26/16	07/27/16	2d
50	7	Ross - Recover barge systems #1 & #2	07/27/16	07/30/16	4d
51	8	Nanuq - Recover barge systems #3 & #4	07/27/16	07/30/16	4d
52	9	Alviq - Recover Burger A #6 & #7	07/28/16	07/28/16	1d
53	10	Dino - Recover Burger A #3 & #4	07/28/16	07/28/16	1d
54	11	Alviq - Transit Burger to Kotzebue	07/29/16	07/30/16	2d
55	12	Dino - Transit Burger to Kotzebue	07/29/16	07/30/16	2d
56	13	Alviq - Transfer 4 - 15mt anchors to Ross and Nanuq	07/31/16	08/01/16	2d
57	14	Dino - Transfer 4 - 15mt anchors to Ross and Nanuq	07/31/16	08/01/16	2d
58	15	Ross - Receive anchors from Alviq and Dino	07/31/16	08/01/16	2d
59	16	Nanuq - Receive anchors from Alviq and Dino	07/31/16	08/01/16	2d
60	17	Alviq - Transit Kotzebue to Sivulliq	08/02/16	08/05/16	4d
61	18	Dino - Transit Kotzebue to Sivulliq	08/02/16	08/05/16	4d
62	19	Ross - Transit Kotzebue to Dutch Harbor	08/02/16	08/05/16	4d
63	20	Nanuq - Transit Kotzebue to Dutch Harbor	08/02/16	08/05/16	4d
64	21	Ross - Offload anchors for shipping	08/05/16	08/07/16	3d
65	22	Nanuq - Offload anchors for commercial shipping	08/05/16	08/07/16	3d
66	23	Crew change / fuel / resupply in Dutch (Ross/Nanuq)	08/05/16	08/07/16	3d
67	24	Alviq - Recover Sivulliq #1 - #4	08/06/16	08/09/16	4d
68	25	Dino - Recover Sivulliq #5 - #12	08/06/16	08/09/16	4d
69	26	Ross - Transit Dutch to Burger	08/08/16	08/11/16	4d
70	27	Nanuq - Transit Dutch to Burger	08/08/16	08/11/16	4d
71	28	Crew change / resupply (Alviq/Dino) West Dock	08/09/16	08/09/16	1d

Figure 3 (continued): Example Activity Plan for 4 AHTSV Anchor Retrieval Program

	#	Activity Plan	Start	Finish	Duration	Jul: Jul 3	Jul 10	Jul 17	Jul 24	Jul 31	Aug 7	Aug: Aug 14	Aug 21	Aug
72	29	Aiviq - Transit Sivulliq to Burger	08/10/16	08/13/16	4d									
73	30	Dino - Transit Sivulliq to Burger	08/10/16	08/13/16	4d									
74	31	Ross - Recover Burger A #2 & #6	08/12/16	08/12/16	1d									
75	32	Nanuq - Recover Burger A #5	08/12/16	08/12/16	1d									
76	33	Ross - Secure deck and ready to receive anchors	08/13/16	08/13/16	1d									
77	34	Nanuq - Secure deck and ready to receive anchors	08/13/16	08/13/16	1d									
78	35	Aiviq - Transfer 4 15mt anchors to Nanuq and Ross	08/14/16	08/15/16	2d									
79	36	Dino - Transfer (8) 15mt anchors to Nanuq and Ross	08/14/16	08/15/16	2d									
80	37	Ross - Receive anchors from Aiviq and Dino	08/14/16	08/15/16	2d									
81	38	Nanuq - Receive anchors from Aiviq and Dino	08/14/16	08/15/16	2d									
82	39	Aiviq - Recover Burger A #3	08/16/16	08/17/16	2d									
83	40	Dino - Recover Burger A #1	08/16/16	08/17/16	2d									
84	41	Ross - Transit Burger to Port Clarence	08/16/16	08/17/16	2d									
85	42	Nanuq - Transit Burger to Port Clarence	08/16/16	08/17/16	2d									
86	43	Aiviq - Transit Burger to Kakapo	08/18/16	08/18/16	1d									
87	44	Dino - Transit Burger to Kakapo	08/18/16	08/18/16	1d									
88	45	Ross - Seafasten anchors	08/18/16	08/18/16	1d									
89	46	Nanuq - Seafasten anchors	08/18/16	08/18/16	1d									
90	47	Nanuq refuels Ross if needed	08/18/16	08/18/16	1d									
91	48	Aiviq - Recover Kakapo #1	08/19/16	08/20/16	2d									
92	49	Dino - Recover Kakapo #2	08/19/16	08/20/16	2d									
93	50	Ross - Transit Port Clarence to Dutch	08/19/16	08/21/16	3d									
94	51	Nanuq - Transit Port Clarence to Dutch	08/19/16	08/21/16	3d									
95	52	Aiviq - Transits Kakapo to Dutch Harbor	08/21/16	08/25/16	5d									
96	53	Dino - Transits Kakapo to Dutch Harbor	08/21/16	08/25/16	5d									

1.5 DESCRIPTION OF SIDE SCAN SONAR

The deployed locations of each anchor are known, but components of the mooring systems may have shifted over time and there may be significant marine vegetation growth. The ROV used to manipulate the float ropes is equipped with a camera to give the operators a visual of the equipment once onsite. However, only one vessel is equipped with an ROV; therefore, to facilitate the efficiency and safety of the retrieval process, Fairweather may obtain high resolution geo-referenced imagery using a side scan sonar prior to the beginning of retrieval operations at each site. This imagery will provide the anchor handlers with an accurate picture of exactly where equipment is located to allow safe and efficient retrieval. Fairweather may also survey each site after retrieval is complete to confirm all anchors and associated gear have been removed.

The side scan sonar survey will be conducted from the R/V *Norseman II*, operated by Olgoonik Fairweather, LLC. The *Norseman II* has operated in the Arctic for industry and research organizations since 2007. This vessel will operate independently from the AHTSVs with the goal of reaching the anchor sites prior to the AHTSVs' arrival. The side scan sonar will be towed over the anchor site array in a grid pattern sufficient to produce a mosaic of the entire site. Each survey is expected to last a period of one to three days. In the event that a multi-beam sonar is used it will be pole mounted of the side of the survey vessel whereas a side scan sonar would be towed. The imagery will be provided immediately to the vessel operators so they will be able to develop a detailed plan for the retrieval based on actual conditions of the equipment. The *Norseman II* will be in the Bering Strait region starting in early June conducting scientific research for other organizations. As soon as the ice allows, the *Norseman II* will transit to the Kotzebue Sound to collect the imagery and then up to the Chukchi Sea. As with the anchor handling vessels, the timing of transiting to the Beaufort Sea will depend on distribution of ice around Point Barrow.

1.6 DESCRIPTION OF RETRIEVAL PROCESS

Once on site, the retrieval of each anchor and associated mooring system typically takes approximately four hours to complete. There are typically two vessels onsite, only one of which will be retrieving an anchor. Depending on weather and number of the mooring lines/anchors, one site is expected be completed between two and seven days. Anchors will be retrieved in one of two ways. The first is by locating the float rope connected to each of the mooring systems with the ROV (if the *Dino Chouest* is the vessel on that site) and retrieving the anchor from the opposite side of the anchor, working towards the anchor itself. The second method will be employed if the float rope cannot be located, or the vessel retrieving does not have an ROV. A grappling hook will be deployed and to grasp the mooring chain along the anchoring system. From that point, the anchor system will be pulled on the back deck with retrieval on the non-anchor side first, then the anchor side, and all the way to the anchor. The side scan imagery is integral to the efficiency of retrieval of these anchor systems.

Over this period, the anchor winch and thrusters will be used to pull to unseat and retrieve anchors from the seafloor. Depending on water depth and anchors depth, this typically takes 15-20 minutes per anchor. Thruster usage while maintaining station using Dynamic Positioning (DP) will vary depending on weather and sea conditions. Thruster percentages are automatically increased and decreased based on the sea state and weather. If weather conditions are poor, the thrusters will need to work harder to maintain position. Anchors at Burger A and Kakapo locations are wet stored (they were not seated deeply in place) and will likely not require unseating.

During the 2012 exploratory program for Shell, detailed sound level measurements were performed of all the various activities and vessels, including anchor handling. Detailed descriptions of the sound measurements and analysis methods are provided in the Shell 2012 90-day report (Austin et al. 2013) and in the Comprehensive Joint Monitoring Report (LGL et al. 2014). Anchor handling activities were found to be the loudest of the activities due to the thrusters working at their highest power during the seating of the anchors. Received levels were measured at 143 dB at 860 m. As further described in Section 6, we assume the unseating of the anchors will be similar in power needed from the vessel, so this source is suitable to estimate the area ensonified for the anchor unseating. Thrusters will only be needed when on site with the anchor being removed.

1.7 ICE FORECASTING AND MANAGEMENT

The anchor retrieval program is located in an area characterized by active sea ice movement, ice scouring, and storm surges. In anticipation of potential ice hazards that may be encountered, we will utilize real-time ice and weather forecasting to identify conditions that could put operations at risk, allowing the vessels to modify their activities accordingly. These observations will be made by experienced ice and weather specialists whose sole duty is to provide information and provide advice on any ice-related threats. These observers and advisors will be based in Anchorage. This real-time ice and weather forecasting will be available to personnel for planning purposes and as a tool to alert the fleet of impending hazardous ice and weather conditions. Potential data sources for ice forecasting and tracking include:

- Potential unmanned aerial support operated by Tulugaq II LLC from vessels for ice scouting.
- Radarsat Data Synthetic Aperture Radar - provides all-weather imagery of ice conditions with very high resolution.
- Moderate Resolution Imaging Spectroradiometer (MODIS) - a satellite providing lower resolution visual and near infrared imagery.
- Other publically available remote sensing satellite data such as Visible Infrared Imaging Radiometer Suite, Oceansat-2 Scatterometer, and Advanced Very High Resolution Radiometer.
- Reports from Ice Specialists on the ice management vessel and anchor handler and from the Ice Observer on the vessels.
- Information from the NOAA ice centers and potentially the University of Colorado.

The proposed 2016 anchor handling fleet will consist of two ice-classed vessels. The only time ice management is likely for this project is around Point Barrow. The goal of the project is to transit into the Beaufort Sea as soon as ice conditions allow, which is typically in late July. If vessels transit into the area and ice moves in, they may be required to manage ice floes. Fairweather does not anticipate active ice management except for a few days near Point Barrow during the transit. Therefore, we have analyzed potential impacts of ice management for two days in the Barrow area.

2.0 DATES, DURATION, AND GEOGRAPHICAL REGION OF ACTIVITIES

The dates and duration of such activity and the specific geographical region where it will occur.

2.1 DATES AND DURATIONS OF ACTIVITIES

Fairweather will retrieve mooring systems that were left as part of Shell's exploration program at five locations: 1) Good Hope Bay in Kotzebue Sound, 2) Burger A site in the Chukchi Sea, 3) Burger V site in the Chukchi Sea, 4) Kakapo in the Chukchi Sea, and 5) Sivulliq site in the Beaufort Sea (Figure 1). Using specialized AHTSVs, the mooring systems are scheduled for retrieval in the open water season of 2016 (July through September). As described in Section 1.4, vessels will mobilize from Dutch Harbor in late June to arrive in Kotzebue area by early July. Multiple retrieval scenarios have been developed to retrieve all of the systems within one season; actual timing of retrieval at each of the sites will depend on vessel configuration, ice, weather, and timing of subsistence activities in Kotzebue and Beaufort Sea (one example provided in Figure 3).

As shown in the proposed workflow scenario (Figure 3), Fairweather anticipates operations to be complete by late August with all vessels out of the theater, with the exception of the *Norseman II*. The *Norseman II* will be conducting scientific research for other organizations and may collect the final site clearance side scan sonar data upon completion of the other contracted work. The anticipated timeframe of final data collection is late September /early October.

The aspects of the retrieval program that have the potential to incidentally harass marine mammals are the underwater noise associated with active anchor handling by vessels (due to use of thrusters when unseating anchors), the use of the side scan sonar, and the potential for ice management. At each site, active anchor retrieval activities with the use of thrusters are expected to occur within two to seven days with the thrusters operating only part of the time; unseating typically takes less than half an hour for each anchor. Additionally, the sonar surveys are expected to take one to three days at each site before and after anchor retrieval. Ice management may potentially occur around Point Barrow; we have assumed two days for purposes of analysis. Therefore, operations that may result in incidental harassment to marine mammals will occur over approximately 10 days total on each site throughout the season with the noise sources operating only part of the time over those days and two potential days around Barrow for ice management.

2.2 GEOGRAPHIC LOCATION

The Kotzebue location is approximately 20 kilometers (km, 12 miles [mi]) offshore of the village of Kotzebue, on the northwest coast of Alaska. The average depth in the Kotzebue project area is approximately 9 meters (m, 29 feet [ft]). The Burger A and Burger V locations are approximately 100 km (64 mi) offshore and approximately 126 km (78 mi) northwest of the closest village of Wainwright. Water depths in the Burger prospect area average 40-48 m (130-157 ft). The Kakapo location is approximately 110 km (68 mi) offshore to the northwest of the village of Point Lay, also on the northwest coast of Alaska. Water depths in the Kakapo area are similar to Burger, averaging 40 m (130 ft). The Sivulliq location is approximately 25 km (15 mi) offshore of the North Slope of Alaska in between Prudhoe Bay to the west and Kaktovik to the east. The average water depth at the Sivulliq project area is approximately 30-35 m (98-115 ft).

3.0 TYPE AND ABUNDANCE OF MARINE MAMMALS IN PROJECT AREA

The species and numbers of marine mammals likely to be found within the activity area.

3.1 SPECIES AND NUMBER IN THE PROJECT AREA

Cetaceans and seals are the subject of this IHA application to NMFS. The two marine mammal species (Pacific walrus [*Odobenus rosmarus*] and polar bear [*Ursus maritimus*]) managed by the U.S. Fish & Wildlife Service (USFWS) are not discussed further in this application. Marine mammal species under the jurisdiction of the NMFS that may occur in the area of the planned anchor retrieval program include nine cetacean species and four species of seals. A species list, Endangered Species Act (ESA) status, if applicable, typical habitat and latest abundance estimate are listed in Table 4. For this summary and subsequent analysis, we have considered any waters north of the Bering Strait to be the Chukchi Sea.

Three of these species, the bowhead, humpback, and fin whales, are listed as “endangered” under the ESA. The bowhead whale is more common in the area than the other two species. The fin whale is unlikely to be encountered near the planned activities, but a few sightings in the Chukchi Sea have been reported in recent years (Reiser et al. 2009a; Hartin et al. 2013; Bisson et al. 2013; Clarke et al. 2013). Similarly, humpback whales are not known to regularly occur in the Chukchi Sea; however, several humpback sightings have been recorded during vessel-based and aerial surveys in the Chukchi Sea (Reiser et al. 2009a, Clarke et al. 2011; Bisson et al. 2013; Clarke et al. 2013). Two species of seal (ringed seal and bearded seal) were recently listed as “threatened” species under the ESA (NMFS 2012a,b). Both species are common in the Chukchi Sea. The Beringia bearded seal Distinct Population Segment (DPS) is identified as “Candidate” in Table 4. Included in Section 4 is the information about the species that are known to or may be present in the area where anchor retrieval activities will occur.

Table 4. Species, Conservation Status, Habitat, and Abundance Estimates of Marine Mammals Inhabiting the Area

Species	Conservation Status	Habitat	Minimum Population Estimate[1]
Beluga whale (*Delphinapterus leucas*) – Eastern Chukchi Stock	ESA – Not Listed	Offshore, coastal, ice edges	3,710[2]
Beluga whale (*Delphinapterus leucas*) – Beaufort Stock	ESA – Not Listed	Offshore, coastal, ice edges	32,453
Narwhal (*Monodon monoceros*)	ESA – Not Listed	Offshore, ice edge	Rare
Killer whale (*Orcinus orca*)	ESA – Not Listed	Widely distributed	2,084[3]
Harbor porpoise (*Phocoena phocoena*) – Bering Sea Stock[4]	ESA – Not Listed	Coastal, inland waters, shallow offshore waters	48,215
Bowhead whale (*Balaena mysticetus*) – Western Arctic Stock	ESA – Endangered	Pack ice, coastal	13,796
Gray whale (*Eschrichtius robustus*) – Eastern Pacific Stock	ESA – Not Listed	Coastal, lagoons, shallow offshore waters	19,126[5]
Minke whale (*Balaenoptera acutorostrata*)	ESA – Not Listed	Shelf, coastal	810[6]
Humpback whale (*Megaptera novaeangliae*) – Western North Pacific Stock	ESA – Endangered	Shelf slope, mostly pelagic	6,000-14,000[7]
Fin whale (*Balaenoptera physalus*) – Northeast Pacific Stock	ESA – Endangered	Shelf, coastal	1,368[8]
Bearded seal (*Erignathus barbatus*)	ESA – Candidate	Pack ice, shallow offshore waters	155,000[9]
Spotted seal (*Phoca largha*)	ESA – (Arctic DPS Not Listed)	Pack ice, coastal haul outs, offshore	391,000
Ringed seal (*Pusa hispida*)	ESA – Threatened	Land-fast & pack ice, offshore	300,000[10]
Ribbon seal (*Histriophoca fasciata*)	ESA – Not Listed	Pack ice, offshore	90,000-100,000[11] 49,000[12]

1) All minimum population estimates are taken from the Alaska Marine Mammal Stock Assessments, 2014 (Allen and Angliss 2015), unless otherwise noted.
2) The Alaska Scientific Review Group concluded that the population estimate of 3,710 belugas can serve as the estimated minimum population size because the survey did not include all areas where beluga are known to occur (Small and DeMaster 1995).
3) Minimum estimate for Eastern Chukchi and Beaufort Sea (Allen and Angliss 2014).
4) This is the closest stock of harbor porpoise to the project area as presented in Allen and Angliss 2014.
5) North Pacific gray whale population (Laake et al. 2009).
6) Central-eastern and southeastern Bering (Allen and Angliss 2015).
7) Bering Sea and Aleutian Islands estimated population size (Allen and Angliss 2015).
8) Best provisional estimate of the fin whale population west of the Kenai Peninsula (Allen and Angliss 2015).
9) Based on studies by Ver Hoef et al. (2010), Fedoseev (2000) and Bengtson et al. (2005), for purposes of the ESA status review of the species, Cameron et al. (2010) estimated about 125,000 bearded seals in the Bering

Sea and 27,000 bearded seals in the Chukchi Sea. Cameron et al. (2010) did not present population estimates for the East Siberian and Beaufort Seas, but did estimate that the Beringia DPS contained approximately 155,000 bearded seals.

10) Using the most recent estimates from surveys by Bengtson et al. (2005) and Frost et al. (2004) in the late 1990s and 2000, for purposes of the ESA status review of the species, Kelly et al. (2010) estimated the total population in the Alaskan Chukchi and Beaufort Seas to be at least 300,000 ringed seals, which is likely an underestimate (Kelly et al. 2010).
11) Bering Sea, (Burns 1981a).
12) Eastern and Central Bering Sea (Allen and Angliss 2014).

4.0 DESCRIPTION OF MARINE MAMMALS IN PROJECT AREA

A description of the status, distribution, and seasonal distribution of the affected species or stocks of marine mammals likely to be affected by such activities.

A description of the status, distribution, and seasonal distribution of the affected species or stocks of marine mammals listed in Table 4 is presented in the following pages. Information provided in this section relates to the proposed anchor retrieval activities in three specific regions (see list below). We encourage the reader to refer to the latest Alaska Marine Mammal Stock Assessment Report (Allen and Angliss 2015) for a more detailed discussion on each species, as well as the numerous previous environmental compliance documents associated with Shell's exploration program.

The marine mammal species under NMFS jurisdiction most likely to occur in the Chukchi Sea are:

- Bearded Seal (*Erignathus barbatus*)
- Beluga Whale (*Delphinapterus leucas*) – Eastern Chukchi Stock
- Bowhead Whale (*Balaena mysticetus*)
- Gray Whale (*Eschrichtius robustus*) – Eastern Pacific Stock
- Harbor Porpoise (*Phocoena phocoena*) – Bering Sea Stock
- Ringed Seal (*Pusa hispida*)
- Spotted Seal (*Phoca largha*)

The Marine mammal species under NMFS jurisdiction most likely to occur in the Beaufort Sea are:

- Bearded Seal (*Erignathus barbatus*)
- Beluga Whale (*Delphinapterus leucas)* – Beaufort Stock
- Bowhead Whale (*Balaena mysticetus)*
- Gray Whale (*Eschrichtius robustus*) – Eastern Pacific Stock
- Harbor Porpoise (*Phocoena phocoena*) – Bering Sea Stock
- Ringed Seal (*Pusa hispida*)
- Spotted Seal (*Phoca largha*)

The narwhal is considered an extralimital species and is not discussed in this Section. Ribbon seal sightings are extremely rare and are therefore not discussed.

4.1 BELUGA WHALE

All stocks of beluga whales are discussed is this section as life history, group structure, behaviors, and physiological characteristics are similar. Specific information relating to individual stocks is discussed in sub-headings if available. The beluga whale is an Arctic and subarctic species that includes several populations in Alaska and northern European waters. It has a circumpolar distribution in the Northern Hemisphere and occurs between 50ºN and 80ºN latitude (Reeves et al. 2002). During the winter, they occur in offshore waters associated with pack ice. In the spring, they migrate to warmer coastal estuaries, bays, and rivers where they may molt (Finley 1982; Suydam 2009) and give birth to and care for their calves (Sergeant and Brodie 1969). Annual migrations can be more than thousands of km (Richard et al. 2001).

In Alaska, beluga whales comprise five distinct stocks: Beaufort Sea, eastern Chukchi Sea, eastern Bering Sea, Bristol Bay, and Cook Inlet (O'Corry-Crowe et al. 1997). For the planned anchor retrieval activities, all but the Cook Inlet stock may be encountered. Satellite transmitters on a few whales from the Beaufort

Sea, Chukchi Sea and Eastern Bering Sea stocks have lasted through the winter demonstrating that beluga whales from these summering areas overwinter in the Bering Sea and the stocks may use separate wintering locations (Suydam 2009).

4.1.1 Eastern Chukchi Stock

The Eastern Chukchi Sea beluga whales are not designated as depleted under the MMPA or listed as threatened or endangered under the ESA. The Alaska Scientific Review Group concluded that the population estimate of 3,710 belugas can serve as the estimated minimum population size because the survey did not include all areas where beluga are known to occur (Small and DeMaster 1995). Because the survey data are more than 8 years old, it is not considered a reliable minimum population estimate for calculating a potential biologic removal (PBR), and Minimum Population Estimate (NMIN) is considered unknown.

Eastern Chukchi Sea belugas move into coastal areas, including Kasegaluk Lagoon, in late June and animals are sighted in the area until about mid-July (Frost et al. 1993). Satellite tags attached to eastern Chukchi belugas captured in Kaseguluk Lagoon during the summer showed these whales traveled 1,100 km north of the Alaska coastline, into the Canadian Beaufort Sea within three months (Suydam et al. 2001b). This movement indicated some overlap in distribution with the Beaufort Sea beluga whale stock during late summer. Satellite telemetry data from 23 whales tagged during 1998-2007 suggest variation in movement patterns for different age and/or sex classes during July-September (Suydam et al. 2005b). Adult males used deeper waters and remained there for the duration of the summer; all belugas that moved into the Arctic Ocean (north of 75°N) were males, and males traveled through 90% pack ice cover to reach deeper waters in the Beaufort Sea and Arctic Ocean (79-80°N) by late July/early August. Adult and immature female belugas remained at or near the shelf break in the Chukchi Sea. After October, only three tags continued to transmit, and those whales migrated south through the eastern Bering Strait into the northern Bering Sea, remaining north of Saint Lawrence Island over the winter. The subsistence take of beluga whales from the eastern Chukchi Sea stock is provided by the Alaska Beluga Whale Committee (ABWC). The most recent subsistence harvest estimates for the stock are provided in Table 1 of the Eastern Chukchi Beluga Whale Stock (Allen and Angliss 2015). Given these data, the annual subsistence take by Alaska Native hunters averaged 57.4 belugas landed during the 5-year period 2008-2012 based on reports from ABWC representatives and on-site harvest monitoring. This population is considered to be stable (Allen and Angliss 2015). It is assumed that beluga whales from the eastern Chukchi stock winter in the Bering Sea (Allen and Angliss 2014).

Summer densities of beluga whales in offshore waters are expected to be low, with somewhat higher densities in ice-margin and nearshore areas. Past aerial surveys have recorded few belugas in the offshore Chukchi Sea during the summer months (Moore et al. 2000). Aerial surveys of the Chukchi Sea from 2008-2012 flown by the National Marine Mammal Laboratory (NMML) as part of the Chukchi Sea Offshore Monitoring in Drilling Area (COMIDA) project, now part of the Aerial Survey of Arctic Marine Mammals (ASAMM) project, reported 10 beluga sightings (22 individuals) in offshore waters during 22,154 km of on-transect effort. Larger groups of beluga whales were recorded in nearshore areas, especially in June and July during the spring migration (Clarke and Ferguson in prep; Clarke et al. 2012, 2013). Additionally, only one beluga sighting was recorded during >80,000 km of visual effort during good visibility conditions from industry vessels operating in the Chukchi Sea in September-October of 2006-2010 (Hartin et al. 2013). If belugas are present during the summer, they are more likely to occur in or near the ice edge or close to shore during their northward migration.

In the fall, beluga whale densities offshore in the Chukchi Sea are expected to be somewhat higher than in the summer because individuals of the eastern Chukchi Sea stock and the Beaufort Sea stock will be migrating south to their wintering grounds in the Bering Sea (Allen and Angliss 2014).

4.1.2 Beaufort Stock

Duval (1993) reported an estimate of 21,000 belugas for the Beaufort Sea stock, similar to that reported by Seaman et al. (1985). The most recent aerial survey was conducted in July 1992, and resulted in an estimate of 19,629 (Coefficient of Variance [CV] = 0.229) beluga whales in the eastern Beaufort Sea (Harwood et al. 1996). To account for availability bias with a correction factor (CF) identified by Duval (1993), the population estimate is 39,258 (19,629 × 2) animals. The current population trend of the Beaufort Sea stock of beluga whales is stable or increasing (Allen and Angliss 2015). Recent and historical aerial surveys off the Mackenzie River Delta indicate that the stock is at least stable or increasing (Harwood and Kingsley 2013). There are no data to suggest the Beaufort Sea stock is declining. The subsistence take of beluga whales from this stock within U.S. waters is reported by the ABWC. Given the most recent Alaska Native subsistence harvest estimates (see Allen and Angliss 2015, Table 1) of the Beaufort Sea Beluga Whale Stock, the annual subsistence take by Alaska Native hunters averaged 65.6 belugas during the 5-year period from 2008 to 2012.

4.2 KILLER WHALE

Killer whales are found throughout the North Pacific. Along the west coast of North America, killer whales occur along the entire Alaskan coast (Braham and Dahlheim 1982) through the Aleutian Islands to the Bering and Chukchi seas (Allen and Angliss 2014). Killer whales appear to prefer coastal areas, but are also found in deep water (Dahlheim and Heyning 1999). The greatest abundance is thought to be within 800 km (497 mi) of major continents (Mitchell 1975) and the highest densities occur in areas with abundant prey. The Alaska resident stock includes killer whales from southeastern Alaska to the Aleutian Islands and Bering Sea (Allen and Angliss 2015). Killer whales from the Alaska resident or transient stocks could occur in the Chukchi Sea during summer or fall, although transients would be more likely (Allen and Angliss 2015). Killer whales probably do not occur regularly in the Beaufort Sea, although sightings have been reported (Lowry et al. 1987, George and Suydam 1998). George et al. (1994) reported that they and local hunters see a few killer whales at Point Barrow each year. Killer whales are more common southwest of Barrow in the southern Chukchi Sea and the Bering Sea. Based on photographic techniques, ~100 animals have been identified in the Bering Sea (Alaska Department of Fish & Game [ADFG] 1994).

The number of killer whales likely to occur in the Chukchi Sea during the planned activity is low. Protected species observers (PSOs) onboard industry vessels in the Chukchi Sea have recorded 1-2 killer whale sightings in most years since 2006 (Funk et al. 2010; Reiser et al. 2011; Hartin et al. 2013; Bisson et al. 2013). Observers on Chukchi Sea Environmental Studies Program (CSESP) vessels reported two sightings of killer whales in 2008 and three sightings of 41 individuals in 2012 (Aerts et al. 2013). No visual or acoustic detections were recorded during the Chukchi Acoustic, Oceanographic, and Zooplankton (CHAOZ) surveys in 2010–2011 (NOAA 2010, 2011). COMIDA aerial surveys in 2008–2011 did not detect any killer whales (Clarke et al. 2011, 2012); however, two sightings of 18 killer whales were recorded in 2012 (Clarke et al. 2013). There are no reports of a subsistence harvest of killer whales in Alaska (Allen and Angliss 2015).

4.3 HARBOR PORPOISE

The harbor porpoise is a small odontocete that inhabits shallow, coastal, temperate, subarctic, and arctic waters in the Northern Hemisphere (Read 1999). In Alaska, the harbor porpoise ranges from Point Barrow, south along the Alaska coast (Gaskin 1984). Harbor porpoises occur mainly in shelf areas where they can dive to depths of at least 220 m (722 ft) and stay submerged for more than 5 minutes (Harwood and Wilson 2001) feeding on small schooling fish (Read 1999). Harbor porpoises typically occur in small groups of only a few individuals and tend to avoid vessels (Richardson et al. 1995b). The subspecies *Phocoena vomerina* ranges from the Chukchi Sea, Pribilof Islands, Unimak Island, and the southeastern shore of Bristol Bay south to San Luis Obispo, California. Point Barrow, Alaska, is the approximate northeastern extent of their regular range (Suydam and George 1992), though there are extralimital records east to the mouth of the Mackenzie River in the Northwest Territories, Canada and recent sightings in the Beaufort Sea in the vicinity of Prudhoe Bay during surveys in 2007 and 2008 (Lyons et al. 2009).

Alaskan harbor porpoises have been divided into three groups for management purposes. These groups include animals from southeast Alaska, Gulf of Alaska, and Bering Sea populations. The southeast Alaska group is not discussed in this document. Harbor porpoises present in the Chukchi Sea belong to the Bering Sea group, which includes animals from Unimak Pass northward. Suydam and George (1992) suggested that harbor porpoises occasionally occur in the Chukchi Sea and reported nine records of harbor porpoise in the Barrow area in 1985–1991. More recent vessel-based surveys in the Chukchi Sea found that harbor porpoises were commonly encountered during summer and fall from 2006 to 2010 (Hartin et al. 2013). There were 14 sightings of harbor porpoises during 2008–2012 CSESP surveys and several sightings of harbor porpoises during CHAOZ surveys north of Point Hope (Aerts et al. 2013; NOAA 2010, 2011). Subsistence hunters in Alaska have not been reported to take from this stock of harbor porpoise (Allen and Angliss 2015).

4.4 BOWHEAD WHALE

Western Arctic bowhead whales are distributed in seasonally ice-covered waters of the Arctic and near-Arctic, generally north of 60°N and south of 75°N in the western Arctic Basin (Braham 1984; Moore and Reeves 1993). The only stock found within U.S. waters is the Western Arctic stock also known as the Bering-Chukchi-Beaufort stock (Rugh et al. 2003) or Bering Sea stock (Burns et al. 1993). The western arctic stock is also the largest stock. It includes whales that winter in the Bering Sea and migrate through the Bering Strait, Chukchi Sea, and Alaskan Beaufort Sea to the Canadian Beaufort Sea where they feed during the summer. Visual and satellite tracking data show that many bowhead whales continue migrating west past Barrow and through the northern Chukchi Sea to Russian waters before turning southeast toward the Bering Sea (Moore et al. 1995; Mate et al. 2000; Quakenbush et al. 2010a). Some bowheads reach ~75ºN latitude during the westward fall migration (Quakenbush et al. 2010b). The majority of the Western Arctic stock migrates annually from wintering areas (December to March) in the northern Bering Sea, through the Chukchi Sea in the spring (April through May), to the eastern Beaufort Sea where they spend much of the summer (June through early to mid-October) before returning again to the Bering Sea to overwinter (Braham et al. 1980; Moore and Reeves 1993; Quakenbush et al. 2010a). Some bowheads are found in the western Beaufort, Chukchi and Bering Seas in summer, and these are thought to be a part of the expanding Western Arctic stock (Rugh et al. 2003, Clarke et al. 2013). Prior to 2012, the majority of satellite-tagged whales crossed the Chukchi Sea quickly; however, tagged whales in 2012 remained in the central Chukchi Sea concurrently with drilling operations before entering the Bering Sea in December, possibly due to opportunistic feeding (Quakenbush et al. 2013). Bowhead whales were encountered in the

Chukchi Sea in mid-November in 2012 during other industry activities (LGL et al. 2014). Bowhead whales that are thought to be part of the Western Arctic stock may also occur in small numbers in the Bering and Chukchi seas during the summer (Rugh et al. 2003). Thomas et al. (2009) also reported bowhead sightings in 2006 and 2007 during summer aerial surveys in the Chukchi Sea. All sightings were recorded in the northern portion of the study area, north of 70ºN latitude. Autumn bowhead whaling near Barrow normally begins in mid-September to early October. Whaling near Barrow can continue into October or early November, depending on the available quota and weather conditions.

During winter and spring, bowhead whales are closely associated with sea ice (Moore and Reeves 1993; Quakenbush et al. 2010a). The bowhead spring migration follows fractures in the sea ice around the coast of Alaska, generally in the shear zone between the shorefast ice and the mobile pack ice (Allen and Angliss 2015). Spring migration through the Chukchi Sea occurs through offshore ice leads, generally from March through mid-June (Braham et al. 1984; Moore and Reeves 1993), well before the onset of the planned anchor handling activities. During the summer, most of the population is in relatively ice-free waters in the southeastern Beaufort Sea (e.g., Richardson et al. 1987; Davies 1997). Fall migration into Alaskan waters is primarily during September and October. However, in recent years a small number of bowheads have been seen or heard offshore from the Prudhoe Bay region during the last week of August (Treacy 1993; LGL and Greeneridge 1996; Greene 1997; Greene et al. 1999; Blackwell et al. 2004, 2009; Greene et al. 2007). Satellite tracking of bowheads has also shown that some whales move to the Chukchi Sea prior to September (Quakenbush et al. 2010b). Summer aerial surveys conducted in the western Beaufort Sea during July and August of 2012 and 2013 have had relatively high sighting rates of bowhead whales, including cows with calves and feeding animals (Clarke et al. 2013; NMML, unpublished data, available at: http://www.afsc.noaa.gov/nmml/cetacean/bwasp/flights_2013.php as cited in Allen and Angliss 2015). During the autumn migration through the Beaufort Sea, bowhead whales select shelf waters in all but "heavy ice" conditions, when they select slope habitat (Moore et al. 2000). Some bowheads arrive in coastal areas of the eastern Canadian Beaufort Sea and Amundsen Gulf in late May and June, but most may remain among the offshore pack ice of the Beaufort Sea until mid-summer. After feeding primarily in the Canadian Beaufort Sea and Amundsen Gulf, bowheads migrate westward from late August through mid- or late-October. Heavy ice years in the autumn in the Beaufort Sea are becoming less common because of the retreat of Arctic sea ice (Allen and Angliss 2015). Bowheads commonly interrupt their migration to feed along the Alaskan Beaufort Sea coast (Ljungblad et al. 1986; Lowry 1993; Landino et al. 1994; Würsig et al. 2002; Lowry et al. 2004) and their stop-overs vary in duration from a few hours to a few weeks (Koski et al. 2002). Westbound bowheads typically reach the Barrow area in mid-September, and remain there until late October (e.g., Brower 1996). However, over the years, local residents report having seen a small number of bowhead whales feeding off Barrow or in the pack ice off Barrow during the summer. In winter in the Bering Sea, bowheads often use areas with ~100% sea ice cover, even when polynas are available (Quakenbush et al. 2010a).

Evidence suggests that bowhead whales feed on concentrations of zooplankton throughout their range (Allen and Angliss 2015). Likely or confirmed feeding areas include Amundsen Gulf and eastern Canadian Beaufort; central and western U.S. Beaufort Sea; Wrangel Island; and the coast of Chukotka, between Wrangel Island and the Bering Strait (Quakenbush et al. 2010a, 2010b; Lowry et al. 2004; Clarke and Ferguson 2010a; Ashjian et al. 2010; Okkonen et al. 2011; Clarke et al. 2012; NMML, unpublished data, available at: http://www.afsc.noaa.gov/nmml/cetacean/bwasp/flights_2013.php as cited in Allen and Angliss 2015). Bowheads have also been observed feeding during the summer in the northeastern Chukchi

Sea (Clarke and Ferguson 2010b). The nearest of these known feeding areas to the proposed operations in the Chukchi Sea is just east of Pt. Barrow, which is approximately 250 km from the prospect area.

Up to the early 1990s, the population size was believed to be increasing at a rate of about 3.2 percent per year (Zeh et al. 1996) despite annual subsistence harvests of 14–74 bowheads from 1973 to 1997 (Suydam et al. 1995a, b). A census in 2001 yielded an estimated annual population growth rate of 3.4 percent (95 percent confidence interval [CI], 1.7–5 percent) from 1978 to 2001 and a population size (in 2001) of ~10,470 animals (George et al. 2004; revised to 10,545 by Zeh and Punt 2005). A photo identification population estimate from data collected in 2004 estimated the population (in 2004) to be 12,631 (Koski et al. 2010), which further supports the estimated 3.4 percent population growth rate. Most recently, Givens et al. (2013) estimated the population to be 16,892 individuals in 2011. Assuming a continuing annual population growth of 3.7 percent (Givens et al. 2013), the 2015 bowhead population may number around 19,534 animals. Although apparently recovering well, the Western Arctic bowhead population is currently listed as endangered under the ESA and is classified as a strategic stock by NMFS and depleted under the MMPA (Allen and Angliss 2015).

Bowhead densities estimated from data collected on industry vessels in the Chukchi Sea were higher in fall than summer in 2006, 2008, and 2010 with very little industry activity having occurred in 2009 and 2011 (Hartin et al. 2013). In 2007, bowhead whales were observed by aerial surveys feeding in the Beaufort Sea into September, which may have delayed the bowhead whale migration into the Chukchi and resulted in a reduction of fall sightings in the Chukchi Sea (Christie et al. 2010) in that year. During CSESP surveys in 2008 and 2009, all bowhead sightings occurred in October (Brueggeman 2009, 2010). During the 2010 surveys all but one sighting occurred in October (Aerts et al. 2011). These sightings coincided with increased bowhead whale call detections on acoustic recorders during October of 2009 and 2010. Increases in bowhead whale call detections moved from the northeast array near Barrow to the southwest array from late September to December 2009, consistent with the overall southwest fall migration of bowhead whales through the Chukchi Sea (Delarue et al. 2011). Aerial surveys of offshore portions of the Chukchi Sea from 2008–2012 have shown a relatively consistent pattern of few bowhead whales being present in June–August, and then increasing numbers in September and October (Clarke et al. 2011, 2012, 2013).

Most spring-migrating bowhead whales would likely pass through the Chukchi Sea prior to the start of the planned anchor handling activities. However, a few whales that may remain in the Chukchi Sea during the summer could be encountered during the anchor handling activities or by transiting vessels. More encounters with bowhead whales would be likely to occur during the westward fall migration in late September through October. An ongoing global positioning system (GPS) tagging study (Quakenbush et al. 2013) has provided information on fall bowhead movements across the Chukchi Sea. Most bowheads migrating in September and October appear to transit across the northern portion of the Chukchi Sea to the Chukotka coast before heading south toward the Bering Sea (Quakenbush et al. 2009). Some of these whales have traveled well north of the planned operations, but others have passed near to, or through, the proposed project area. In addition to other planned mitigation, Fairweather will operate in consultation with stakeholders to avoid disturbance to subsistence bowhead whaling activities in the Chukchi and Beaufort Seas, should such a subsistence bowhead hunt occur during the period of planned 2016 anchor handling activities. There have been no known conflicts between industry and bowhead subsistence users in the Alaskan Arctic since the adoption of conflict avoidance measures in 2006.

By July, most bowhead whales are northeast of the Chukchi Sea, within or migrating toward their summer feeding grounds in the eastern Beaufort Sea. No bowheads were reported during 10,686 km of on-transect effort in the Chukchi Sea by Moore et al. (2000). Bowhead whales were also rarely sighted in July-August of 2006-2010 during aerial surveys of the Chukchi Sea coast (Thomas and Koski 2013). This is consistent with movements of tagged whales (ADFG 2010), all of which moved through the Chukchi Sea by early May 2009, and tended to travel relatively close to shore, especially in the northern Chukchi Sea.

During the fall, bowhead whales that summered in the Beaufort Sea and Amundsen Gulf migrate west and south to their wintering grounds in the Bering Sea making it more likely those bowheads will be encountered in the Chukchi Sea at this time of year. Moore et al. (2000) reported 34 bowhead sightings during 44,354 km of on-transect survey effort in the Chukchi Sea during September-October. Thomas and Koski (2013) also reported increased sightings on coastal surveys of the Chukchi Sea during October and November of 2006-2010. GPS tagging of bowheads appear to show that migration routes through the Chukchi Sea are more variable than through the Beaufort Sea (Quakenbush et al. 2010b). Some of the routes taken by bowheads remain well north of the planned anchor handling activities while others have passed near to or through the area. Kernel densities estimated from GPS locations of whales suggest that bowheads do not spend much time (e.g. feeding or resting) in the north-central Chukchi Sea near the area of planned activities (Quakenbush et al. 2010b). However, tagged whales did spend a considerable amount of time in the north-central Chukchi Sea in 2012, despite ongoing industrial activities in the region (ADFG 2012).

4.5 GRAY WHALE

There are two populations in the North Pacific: a relic population, which survives in the Western Pacific, summers near Sakhalin Island far from the area of the planned anchor handling activities and therefore not further discussed, and the eastern Pacific (often referred to as the California) gray whale population. Eastern Pacific gray whales calve in the protected waters along the west coast of Baja California and the east coast of the Gulf of California from January to April (Swartz and Jones 1981; Jones and Swartz 1984). At the end of the calving season, most of these gray whales migrate about 5,000 mi (8,000 km), generally along the west coast of North America, to the main summer feeding grounds in the northern Bering and Chukchi seas (Tomilin 1957; Rice and Wolman 1971; Nerini 1984; Moore et al. 2003; Bluhm et al. 2007). Most gray whales begin the southward migration in November with breeding and conception occurring in early December (Rice and Wolman 1971).

Gray whale densities are expected to be much higher in the summer months than during the fall. Most summering gray whales have historically congregated in the northern Bering Sea, particularly off St. Lawrence Island in the Chirikov Basin (Moore et al. 2000), and in the southern Chukchi Sea. More recently, Moore et al. (2003) suggested that gray whale use of Chirikov Basin has decreased, likely as a result of the effects of changing currents resulting in altered secondary productivity dominated by lower-quality food. Coyle et al. (2007) noted that ampeliscid amphipod production in the Chirikov Basin had declined by 50 percent from the 1980s to 2002-2003 and that as little as 3-6 percent of the current gray whale population could consume 10-20 percent of the ampeliscid amphipod annual production. These data support the hypotheses that changes in gray whale distribution may be caused by changes in food production and that gray whales may be approaching or have surpassed the carrying capacity of their summer feeding areas. Bluhm et al. (2007) noted high gray whale densities along ocean fronts and suggested that ocean fronts may play an important role in influencing prey densities in eastern North Pacific gray whale foraging areas.

Gray whales routinely feed in the Chukchi Sea during the summer. The northeastern-most of the recurring feeding areas is in the northeastern Chukchi Sea southwest of Barrow (Clarke et al. 1989). Moore et al. (2000) reported that during the summer, gray whales in the Chukchi Sea were clustered along the shore primarily between Cape Lisburne and Point Barrow and were associated with shallow, coastal shoal habitat. In autumn, gray whales were clustered near shore at Point Hope and between Icy Cape and Point Barrow, as well as in offshore waters southwest of Point Barrow at Hanna Shoal and northwest of Point Hope. The distribution of gray whales was different during aerial surveys in the Chukchi Sea in 2006 than in 2007–2008 and 2010 (Thomas and Koski 2013). In 2006, gray whales were most abundant along the coast south of Wainwright and offshore of Wainwright (Thomas and Koski 2013). In the following years, gray whales were most abundant in nearshore areas from Wainwright to Barrow (Thomas and Koski 2013). Gray whales occur regularly near Point Barrow, but historically only a small number have been sighted in the Beaufort Sea east of Point Barrow; vessel based surveys also indicate that gray whales occur more frequently in nearshore waters of the Chukchi Sea. Approximately 90 percent of gray whales seen during CSESP surveys in 2012 occurred in waters close to Wainwright, similar to results from surveys in previous years (Aerts et. al 2013). Gray whales were primarily seen nearshore (<50 km) between Point Franklin and Point Barrow in the Chukchi Sea, despite extensive aerial survey efforts further offshore from 2008–2012 (Clarke et al. 2011, 2012, 2013). Scattered sightings of gray whales further offshore do occur, and gray whales have been more common out to 100 km offshore between Icy Cape and Pt. Franklin than along other portions of the coast; however, the use of Hannah Shoal by gray whales appears to have decreased substantially compared to the 1982–1991 survey period (Moore et al. 2000). Gray whales are seen more frequently during July and August, with decreasing numbers of sightings through the fall months (Clarke et al. 2011, 2012, 2013). Although they are most common in portions of the Chukchi Sea close to shore, gray whales may also occur in offshore areas of the Chukchi Sea, particularly over offshore shoals. Gray whales are likely to be in the vicinity of the planned anchor retrieval activities in the Chukchi Sea and are likely to be one of the most commonly encountered cetacean species. In the fall, gray whales may be dispersed more widely through the northern Chukchi Sea (Moore et al. 2000), but overall densities are likely to be decreasing as the whales begin migrating south.

The eastern Pacific gray whale population recovered dramatically from commercial whaling during its protection under the MMPA (and ESA until 1994) and numbered about 29,758 ±3,122 in 1997 (Rugh et al. 2005). However, abundance estimates since 1997 indicate a consistent decline followed by the population stabilizing or gradually recovering. Rugh et al. (2005) estimated the population to be 18,178 ±1,780 in winter 2001-2002 and Rugh et al. (2008) estimated the population in winter 2006-2007 to have been 20,110 ±1,766. The eastern Pacific stock is not considered by NMFS to be endangered or to be a strategic stock.

4.6 MINKE WHALE

In the North Pacific, minke whales occur from the Bering and Chukchi Seas south to near the Equator (Leatherwood et al. 1982). Minke whales are relatively common in the Bering and Chukchi Seas and in the inshore waters of the Gulf of Alaska (Mizroch 1992). Minke whales are known to penetrate loose ice during the summer, and some individuals venture north of the Bering Strait (Leatherwood et al. 1982). Allen and Angliss (2015) recognize two minke whale stocks in U.S. waters:

- The Alaska stock
- The California/Oregon/Washington stock

No estimates have been made for the number of minke whales in the entire North Pacific. However, some information is now available on the numbers of minke whales in some areas of Alaska, shown in Table 4. Minke whale abundance estimates were similar in the central-eastern Bering Sea and the southeastern Bering Sea (Moore et al. 2002). Minke whales occurred throughout the area surveyed, but most sightings of minke whales in the central-eastern Bering Sea occurred along the upper slope in waters 100-200 m deep (Moore et al. 2000); sightings in the southeastern Bering Sea occurred along the north side of the Alaska Peninsula and were associated with the 100 m contour near the Pribilof Islands (Moore et al. 2002).

Minke whales range into the Chukchi Sea, but the level of minke whale use of the Chukchi Sea is unknown. Minke whales have been observed from vessels during previous industry activities in the Chukchi Sea (Hartin et al. 2013; Bisson et al. 2013; Reider et al. 2013) and during aerial surveys conducted by the NMML in 2011 and 2012 (Clarke et al. 2012, 2013). Reider et al. (2013) reported 13 minke whale sightings in the Chukchi Sea in 2013. All but one sighting, however, were observed in nearshore areas despite only minimal monitoring effort in nearshore areas compared to more offshore locations near the Burger prospect in the Chukchi Sea (Reider et al. 2013). Minke whales have been observed 10 times during CSESP vessel surveys from 2008 to 2012 (Aerts et al. 2013). Minke whales could be encountered in relatively low numbers during the planned activities in the Chukchi Sea. Subsistence takes of minke whales by Alaska Natives are rare, but have been known to occur (Allen and Angliss 2015). Only seven minke whales are reported the have been taken for subsistence by Alaska Natives between 1930 and 1987 (C. Allison, International Whaling Commission, United Kingdom, personal communication as cited in Allen and Angliss 2015). The most recent reported catches (two whales) in Alaska occurred in 1989 (Anonymous 1991 as cited in Allen and Angliss 2015), but reporting is likely incomplete. Based on this information, the annual subsistence take averaged zero minke whales during the 5-year period from 2006 to 2010. Minke whales are not designated as depleted under the MMPA or listed as threatened or endangered under the ESA.

4.7 HUMPBACK WHALE

Allen and Angliss (2015) reported that at least three humpback whale populations have been identified in the North Pacific. Two of these stocks may be relevant to the planned anchor handling activities in the Bering and Chukchi Seas. There may be some overlap between the Central and Western North Pacific stocks

- The Central North Pacific stock winters in waters near Hawaii and migrates to British Columbia, Southeast Alaska, and Prince William Sound to Unimak Pass to feed during the summer.
- The Western North Pacific stock winters off the coast of Japan and probably migrates to the Bering Sea to feed during the summer.

In summer the majority of whales from the central North Pacific stock are found in the Aleutian Islands, Bering Sea, Gulf of Alaska, and Southeast Alaska/northern British Columbia. High densities of humpback whales are found in the eastern Aleutian Islands, particularly along the north side of Unalaska Island, and along the Bering Sea shelf edge and break to the north towards the Pribilof Islands. Small numbers of humpback whales are known from a few locations not sampled during the Structure of Populations, Levels of Abundance, and Status of Humpbacks (SPLASH) study, including northern Bristol Bay and the Chukchi and Beaufort Seas (Allen and Angliss 2015).

Humpback whale sightings in the Bering Sea have been recorded southwest of St. Lawrence Island, the southeastern Bering Sea, and north of the central Aleutian Islands (Moore et al. 2002, as cited Allen and Angliss 2014). Recently there have been sightings of humpback whales in the northeastern Chukchi Sea and a single sighting in the Beaufort Sea (Hashagen et al. 2009). Hartin et al. (2013) reported four humpback whales during vessel-based surveys in the Chukchi Sea in 2007, two in 2008, and one in 2010. Five humpback sightings (11 individuals) occurred during CSESP vessel-based surveys in 2009 and 2010 (Aerts et al. 2012), and a single humpback was observed several km west of Barrow during the 2012 CSESP vessel-based survey (Aerts et al. 2013). The ASAMM reported four humpback whale sightings near the coast between Icy Cape and Point Barrow in July and August of 2012, as well as 24 individual humpback whales on 11 September south and east of Point Hope (Clarke et al. 2013). Prior to 2012, only a single humpback had been sighted during the ASAMM (Clarke et al. 2011). Small numbers of humpback whales could occur within or near the anchor handling activities in the Chukchi Sea. There are no reported takes of humpback whales from either stocks discussed above by subsistence hunters in Alaska for the 2008-2012 period (Allen and Angliss 2015).

4.8 FIN WHALE

The fin whale is listed as endangered under the ESA and by the International Union for Conservation of Nature (IUCN) (2013), and in the North Pacific is classified as a strategic stock by NMFS. Fin whales feed in northern latitudes during the summer where their prey includes plankton, as well as shoaling pelagic fish, such as capelin (*Mallotus villosus*; Jonsgård 1966). Within the U.S. waters in the Pacific, fin whales are found seasonally off the coast of North America and in the Bering Sea during the summer (Allen and Angliss 2015). The North Pacific population's summering grounds span from the Chukchi Sea to California (Gambell 1985). Reliable population estimates for the entire North Pacific region are not available (Allen and Angliss 2014). Fin whales were the most common large whale sighted during the Bering Sea shelf surveys in all years except for 1997 and 2004 (Friday et al. 2012, 2013).

Fin whales are being seen increasingly during surveys in the Chukchi Sea in summer (Funk et al. 2010; Aerts et al. 2012; Clarke et al. 2013). Reiser et al. (2009a) reported a fin whale sighting during vessel-based surveys in the Chukchi Sea in 2006. Three fin whale sightings were made in 2008 from industry vessels and NMML survey aircraft also recorded a sighting in the northern Chukchi Sea off of Ledyard Bay in that year (Hartin et al. 2013; Clarke et al. 2011). Observers on CSESP vessel-based surveys recorded one fin whale sighting of three individuals in 2009 and six sightings of 11 individuals in 2012 (Aerts et al. 2013). In 2012, ASAMM reported three fin whale sightings, all of which were south of Point Hope (Clarke et al. 2013), while one sighting was reported from an industry vessel (Bisson et al. 2013). Fin whale calls have been identified on acoustic recordings in the Chukchi Sea by multiple researchers in multiple years (NOAA 2011; Delarue et al. 2012). Subsistence hunters in Alaska and Russia have not been reported to take fin whales from this stock (Allen and Angliss 2015).

4.9 BEARDED SEAL

Bearded seals inhabit the seasonally ice-covered seas of the Northern Hemisphere where they whelp and rear their pups, and molt their coats on the ice in the spring and early summer (Allen and Angliss 2015). Bearded seals feed primarily on benthic organisms, including epifaunal and infaunal invertebrates, and demersal fishes and so are closely linked to areas where the seafloor is shallow (less than 200 m [656 ft]) (Allen and Angliss 2015). In Alaskan waters, bearded seals occur over the continental shelves of the Bering, Chukchi, and Beaufort seas (Burns 1981b). No reliable minimum population estimate of bearded seal abundance is available for the Chukchi Sea (Allen and Angliss 2015), however, the Alaska stock of bearded seals is estimated to be about 155,000 (Beringia DPS, Cameron et al. 2010). No population estimates could be calculated since these densities were not adjusted for haul out behavior.

Bearded seals are primarily benthic feeders, preferring a variety of infaunal and epifaunal invertebrates as well as occasional demersal fishes (Bluhm and Gradinger 2008). They apparently also feed on ice-associated organisms when they are present, and this allows a few bearded seals to live in areas where water depth is considerably greater than 200 m (656 ft) (Cameron et al. 2009). During the summer period, bearded seals occur mainly in relatively shallow areas because they are predominantly benthic feeders (Burns 1981b).

Seasonal movements of bearded seals are directly related to the advance and retreat of sea ice and to water depth (Kelly 1988b). During winter, most bearded seals in Alaskan waters are found in the Bering Sea. In the Chukchi and Beaufort seas, favorable conditions are more limited, and consequently, bearded seals are less abundant there during the winter; although they have occasionally been reported to maintain breathing holes in sea ice and broken areas within the pack ice, particularly if the water depth is <200 m [<656 ft.] (e.g., Harwood et al. 2005). From mid-April to June as the ice recedes, some of the bearded seals that overwinter in the Bering Sea migrate northward through the Bering Strait. During the summer they are found near the widely fragmented margin of sea ice covering the continental shelf of the Chukchi Sea and in nearshore areas of the central and western Beaufort Sea (Allen and Angliss 2015). Bearded seals are likely to be encountered during anchor handling activities, and greater numbers of bearded seals are likely to be encountered if the ice edge occurs nearby.

4.10 SPOTTED SEAL

Spotted seals occur in the Beaufort, Chukchi, Bering, and Okhotsk seas, and south to the northern Yellow Sea and western Sea of Japan (Shaughnessy and Fay 1977). They migrate south from the Chukchi Sea to the Bering Sea in October (Lowry et al. 1998). Spotted seals overwinter in the Bering Sea and inhabit the southern margin of the ice during spring (Shaughnessy and Fay 1977). Boveng et al. (2009) identified three DPSs: the Bering DPS, which includes breeding areas in the Bering Sea; the Okhotsk DPS; and the Southern DPS, which is not discussed in this report. For the purposes of the 2015 stock assessment (Allen and Angliss 2015), the Bering DPS is considered the Alaska stock of the spotted seal.

During spring when pupping, breeding, and molting occur, spotted seals are found along the southern edge of the sea ice in the Okhotsk and Bering seas (Quakenbush 1988; Rugh et al. 1997). In late April and early May, adult spotted seals are often seen on the ice in female-pup or male-female pairs, or in male-female-pup triads. Sub-adults may be seen in larger groups of up to 200 animals. During the summer, spotted seals are found primarily in the Bering and Chukchi seas, but some range into the Beaufort Sea (Rugh et al. 1997; Lowry et al. 1998) from July until September. At this time of year, spotted seals haul out on land part of the time, but also spend extended periods at sea. Spotted seals are commonly seen in bays, lagoons and estuaries, but also range offshore as far north as 69–72ºN latitude. In summer, they are rarely seen on the pack ice, except when the ice is very near shore. As the ice cover thickens with the onset of winter, spotted seals leave the northern portions of their range and move into the Bering Sea (Lowry et al. 1998). Satellite tagging studies showed that seals tagged in the northeastern Chukchi Sea moved south in October and passed through the Bering Strait in November. Seals overwintered in the Bering Sea along the ice edge and made east-west movements along the edge (Lowry et al. 1998).

An extensive fixed-wing aerial survey (767,000 km^2) was conducted during April-May of 2012 and 2013 (Conn et al. 2014). The 2012 survey was used as the basis for the minimum population estimate of the 2014 stock assessment report of 391,000 animals (Allen and Angliss 2015). In the Chukchi Sea, Kasegaluk Lagoon and Icy Cape are important areas for spotted seals. Spotted seals haul out in this region from mid-July until freeze-up in late October or November. Lowry et al. (1998) reported a maximum count of about 2,200 spotted seals in the lagoon during aerial surveys. No spotted seals were recorded along the shore south of Point Lay. Based on satellite tracking data, Frost et al. (1993) reported that spotted seals tagged at

Kasegaluk Lagoon spent 94 percent of the time at sea. Extrapolating the count of hauled-out seals to account for seals at sea would suggest a Chukchi Sea population of about 36,000 animals.

CSESP vessel-based surveys from 2008–2012 recorded 217 spotted seals as well as 756 seals that could not be discerned between ringed and spotted seals (Aerts et al. 2013). In 2014, 14 spotted seals were observed as well as 87 seals that could not be discerned between ringed and spotted seals (Aerts et al. 2014). Observers aboard industry vessels operating in the Chukchi Sea from 2008 to 2010 reported 288 sightings of 355 individual spotted seals (Hartin et al. 2013). Some of the 2035 unidentified seals recorded during those years were likely spotted seals as well. Spotted seals are expected to occur near the planned anchor handling activities in the Chukchi Sea, but they will likely be fewer in number than ringed seals.

4.11 RINGED SEAL

Ringed seals have a circumpolar distribution and occur in all seas of the Arctic Ocean (King 1983). They are closely associated with ice and, in the summer, they often occur along the receding ice edges or farther north in the pack ice (Kelly 1988a). In the North Pacific, they occur in the southern Bering Sea and range south to the seas of Okhotsk and Japan. They are found throughout the Beaufort, Chukchi, and Bering seas (Allen and Angliss 2014). The Alaska stock, part of the Arctic subspecies of ringed seal, has been listed as threatened under the ESA (NMFS 2012b). They remain in contact with ice most of the year and use it as a platform for pupping and nursing in late winter to early spring, for molting in late spring to early summer, and for resting at other times of the year, although land haul outs may be increasingly used because of increases in summer sea ice retreat (Allen and Angliss 2015). This species rarely comes ashore in the Arctic; however, in more southerly portions of its range where sea or lake ice is absent during summer and fall, ringed seals are known to use isolated haul-out sites on land for molting and resting (Härkönen et al. 1998; Trukhin 2000; Kunnasranta 2001; Lukin et al. 2006).

Ringed seals are year-round residents in the Bering Sea, Norton and Kotzebue Sounds, and throughout the Chukchi and Beaufort Seas and are the most frequently encountered seal in the area (Allen and Angliss 2015). They occur as far south as Bristol Bay in years of extensive ice coverage but generally are not abundant south of Norton Sound except in nearshore areas (Frost 1985). During winter, ringed seals occupy land-fast ice and offshore pack ice of the Bering, Chukchi, and Beaufort seas. In winter and spring, the highest densities of ringed seals are found on stable shorefast ice. However, in some areas where there is limited fast ice but wide expanses of pack ice, including the Beaufort Sea, Chukchi Sea and Baffin Bay, total numbers of ringed seals on pack ice may exceed those on shorefast ice (Burns 1970; Stirling et al. 1982; Finley et al. 1983). Adult ringed seals maintain breathing holes in the ice and occupy lairs in accumulated snow (Smith and Stirling 1975) while some sub-adult ringed seals appear to winter near the pack-ice edge in the Bering Sea (Crawford et al. 2012). They give birth in lairs from mid-March through April, nurse their pups in the lairs for 5 to 8 weeks, and mate in late April and May (Smith 1973; Hammill et al. 1991; Lydersen and Hammill 1993).

No estimate for the size of the Alaska ringed seal stock is currently available (Allen and Angliss 2015). Past ringed seal population estimates in the Bering, Chukchi, and Beaufort seas ranged from 1 to 1.5 million (Frost 1985) to 3.3 to 3.6 million (Frost et al. 1988). During aerial surveys in 1999, Bengtson et al. (2005) reported ringed seal densities offshore from Shishmaref to Barrow ranging from 1.0 to 9.6 seals/mi2 (0.4 to 3.7 seals/km^2) and estimated the total Chukchi Sea population at 245,048 animals in 1999. Densities were higher in nearshore than offshore locations. Using the most recent estimates from surveys by Bengtson et al. (2005) and Frost et al. (2004) in the late 1990s and 2000, for purposes of the ESA status review of the species, Kelly et al. (2010) estimated the total population in the Alaskan Chukchi and Beaufort Seas as at least 300,000 ringed seals, which Kelly et al. (2010) state is likely an underestimate since the Beaufort surveys were limited to within 40 km of shore. During April-May in 2012 and 2013, United States (U.S.) and Russian researchers conducted comprehensive and synoptic aerial abundance and distribution surveys of ice-associated seals in the Bering and Okhotsk Seas (Moreland et al. 2013). Preliminary analysis of the U.S. surveys, which included only a small subset of the 2012 data, produced an estimate of about 170,000 ringed seals in the U.S. Exclusive Economic Zone (EEZ) of the Bering Sea in late April (Conn et al. 2014). This estimate does not account for availability bias, thus the actual number of ringed seals is likely much higher, perhaps by a factor of two or more. These data do not include ringed seals in the Chukchi and Beaufort Seas, and so may have provided a low-biased estimate of the abundance of this DPS.

During vessel-based observations from industry activities in the Chukchi Sea, Hartin et al. (2013) reported seal densities (assumed to be primarily ringed seals) from 0.125 to 2.1 seals/mi^2 (0.048 to 0.807 seals/km^2). CSESP vessel-based surveys from 2008 to 2012 recorded 311 ringed seals and 756 seals classified as either ringed or spotted (Aerts et al. 2013). During that same survey in 2014, 26 ringed seals were observed and 87 seals classified as either ringed or spotted seals (Aerts et al. 2014). Estimated densities from CSESP vessel-based surveys from 2008 to 2012 for the combined ringed/spotted seal category ranged from 0.01 seals/mi^2 (0.004 seals/km^2) in July/August of 2009 to 0.3 seals/mi^2 (0.1 seals/km^2) in July/August of 2008 (Aerts et al. 2013). Ringed seals will likely be the most abundant marine mammal species encountered in the Chukchi Sea during anchor retrieval operations.

5.0 REQUESTED TYPE OF INCIDENTAL TAKING AUTHORIZATION

The type of incidental taking authorization that is being requested and the method of incidental taking.

Fairweather requests an IHA from NMFS for the incidental take by harassment (Level B as defined in 50 CFR 216.3) of a small number of marine mammals during its planned anchor retrieval activities in Kotzebue Sound, Chukchi, and Beaufort seas in 2016. The operations outlined in Sections 1 and 2 have the potential to result in 'takes' by 'harassment' of marine mammals by acoustic disturbance during anchor handling operations, potential use of side scan sonar, and ice handling. The effects will depend on the species and the distance and received level of the sound (Section 7). Temporary disturbance or localized displacement reactions are most likely to occur. With implementation of the mitigation and monitoring measures described in Sections 11 and 13, no takes by injury or mortality (Level A) are anticipated, and takes by disturbance (Level B) are expected to be minimized.

6.0 NUMBER OF INCIDENTAL TAKES BY ACTIVITIES

By age, sex, and reproductive condition, the number of marine mammals [by species] that may be taken by each type of taking, and the number of times such takings by each type of taking are likely to occur.

The proposed anchor retrieval operations outlined in Sections 1 and 2 have the potential to temporarily disturb or displace small numbers of marine mammals near the anchor sites. These potential effects, as summarized in Section 7, will not exceed MMPA Level B harassment, as defined by 30 CFR 213.6. The mitigation measures to be implemented during the survey are based on Level B harassment acoustic criteria defined below. No take by injury or death is anticipated with implementation of the mitigation and monitoring measures. The following sections provide information on the applicable noise criteria and a description of the methods used to calculate numbers of marine mammals that may be potentially encountered during the anchor retrieval program.

6.1 APPLICABLE NOISE CRITERIA

Under the MMPA, the NMFS has defined levels of harassment for marine mammals. Level A harassment is defined as "…any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild." Level B harassment is defined as "…any act of pursuit, torment, or annoyance which has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering."

Since 1997, NMFS has been using generic sound exposure thresholds to determine when an activity in the ocean that produces sound might result in impacts to a marine mammal such that a take by harassment might occur (70 FR 1871). NMFS is developing new science-based thresholds to improve and replace the current generic exposure level thresholds, but the criteria have not been finalized (NMFS 2015). The current Level A (injury) threshold for impulse noise is 180 decibels referenced to one micro Pascal root-mean-square (dB re 1 µPa rms) for cetaceans (whales, dolphins, and porpoises) and 190 dB re 1 µPa rms for pinnipeds (seals, sea lions). This zone is referred to as the Exclusion Zone (EZ), in which the goal is to not expose animals within this zone by shutting down activities or not starting until this zone is clear. The current Level B (disturbance) threshold for impulse noise is 160 dB re 1 µPa rms and 120 dB re 1 µPa rms for non-impulse noise for all marine mammals. This zone is referred to as the Safety Zone, in which the goal is to monitor marine mammal behavior in this zone.

6.2 DESCRIPTION OF SOUND SOURCES

6.2.1 Anchor Handling

Vessels will be used to conduct the anchor retrieval operations. Sounds from boats and vessels have been reported extensively (Greene and Moore 1995; Blackwell and Greene 2002, 2005, 2006). Numerous measurements of underwater vessel sound have been performed in support of recent industry activity in the Chukchi and Beaufort Seas. Results of these measurements were reported in various 90-day and comprehensive reports since 2007. For example, Garner and Hannay (2009) estimated sound pressure levels of 100 dB re 1 µPa rms at distances ranging from ~1.5 to 2.3 mi (~2.4 to 3.7 km) from various types of barges. MacDonnell et al. (2008) estimated higher underwater sound pressure levels from the seismic vessel Gilavar of 120 dB re 1 µPa rms at ~13 mi (~21 km) from the source, although the sound level was only 150 dB re 1 µPa rms at 85 ft. (26 m) from the vessel. Like other industry-generated sound, underwater sound from vessels is generally at relatively low frequencies. During 2012, underwater sound from ten (10) vessels in transit, and in two instances towing or providing a tow-assist, were recorded by JASCO in the Chukchi Sea as a function of the Sound Source Characterization (SSC) study required in the Shell 2012 Chukchi Sea drilling IHA. SSC transit and tow results from 2012 include ice management vessels, an anchor handler, OSRV, the Oil Spill Toolkit (OST), support tugs, and OSVs. The recorded sound pressure levels to 120 dB re 1 μPa rms for vessels in transit primarily range from 1.3 - 6.9 km (~0.8 mi – 4.3 mi), whereas the measured 120 dB re 1 μPa rms for the drilling unit Kulluk under tow by the Aiviq in the Chukchi Sea was 19 km (~11.8 mi) on its way to the Beaufort Sea (O'Neill and McCrodan 2012a,b). Measurements of vessel sounds from Shell's 2012 exploration drilling program in the Chukchi Sea are presented in detail in the 2012 Comprehensive Monitoring Report (LGL et al. 2014).

During Shell's 2012 exploratory program, SSVs were conducted of all activities conducted near both Burger and Sivulliq during the open water season (LGL et al. 2014). Results were extracted from underwater sound levels measured using recorders at ranges of 1, 2, 4 and 8 km (3280, 6560, 13,120, and 26,240 ft) from each drill site. Detailed descriptions of the sound measurements and analysis methods can be found in Chapter 3 of the Shell 2012 90-day report to NMFS (Austin et al. 2013). Average received levels were computed for these times and ranges to sound thresholds between 190 and 120 dB were obtained for each drilling activity.

At Burger, the spectral distribution shows that the sound energy during the recording period was concentrated in the decade band from 100–1000 Hz. Peaks in the recorded sound levels often corresponded with the approach and departure of support vessels relative to the recorder. During the period, elevated sound levels were recorded during anchor connection/disconnection (6–9 September, 14–15 September and 20 September). At Sivulliq, the spectral distribution shows that the sound energy during the recording period was also concentrated in the decade band from 100–1000 Hz. Elevated received levels were recorded during anchor handling activities (anchor setting 18–22 August, anchor hook-up 25–27 September).

Anchor handling activities were measured at 143 dB at 860 m, the loudest activity was when "seating" the anchors (LGL et al. 2014). We assume the unseating of anchors will be similar in power needed from the vessel, so this source is suitable to estimate area ensonified. In the report, JASCO extrapolated the distance to the 120 dB threshold using a simple spreading loss of 20 log R, resulting in a radius of 12,000 m. This radius was used to estimate the area ensonified for this application.

In the 2015 Shell IHA application (Shell 2015), JASCO modeled all the various sources expected to exceed received levels of 120 dB using proprietary software. Based on this model, they estimated the area exceeding 120 dB during anchor handling activity to be 1,539 km^2. We have provided both methods for NMFS consideration.

6.2.2 Side Scan Sonar Surveys

If necessary, Fairweather proposes to use a side scan sonar to provide accurate location and imagery of the anchor systems prior to retrieval and after the retrieval to confirm removal of anchor equipment. The device is mounted in a towfish towed by the *Norseman II* (just below the sea surface, or deep-towed). The sound frequencies used in sonar usually range from 100 to 500 kiloHertz (kHz); higher frequencies yield better resolution but less range. The actual device has not been decided, but the following systems would be representative of what would be used:

- A multi-beam echosounder operates at an rms source level of a maximum of 220 dB re 1 μPa @1m. The multi beam echosounder emits high frequency (240 kHz) energy in a fan-shaped pattern of equidistant or equiangular beam spacing. The beam width of the emitted sound energy in the along-track direction is 1.5 degrees, while the across track beam width is 1.8 degrees. (Teledyne Benthos Geophysical 2008; Konsberg 2014)
- A single-beam echosounder operates at an rms source level of approximately 220 dB re 1 μPa @1m. The transducer selected uses a frequency of 210 kHz. The transducer's beam width is approximately 3 degrees. (Teledyne Benthos Geophysical 2008; Konsberg 2014)
- A dual frequency sonar system will operate at about 400 kHz and 900 kHz. The rms source level is 215 dB re 1μPa @ 1m. The sound energy is emitted in a narrow fan-shaped pattern, with a horizontal beam width of 0.45 degrees for 400 kHz and 0.25 degrees at 900 kHz, with a vertical beam width of 50 degrees. (Teledyne Benthos Geophysical 2008; Konsberg 2014)

Assuming a simple spreading loss of 20 log R (where R is radius) with a source level of 220 dB re 1 μPa @1m, the distance to the 160 dB threshold would be 1,000 m (ensonified area of 3.14 km^2). This spreading loss is appropriate for high-frequency pulsed systems. The reason is that the multipath (direct path, surface reflection, bottom reflection, etc.) of short duration pulses arrive at the receivers spaced in time. The rms level therefore should be computed for the strength of the strongest multipath, which will be the direct path. The use of 20 log R is fully appropriate because this path does not interact with surface or bottom (otherwise it would have an even higher coefficient than 20).

In the 2013 Shell 90-day report (Reider et al. 2013), JASCO measured all the various sources associated with the seismic survey program, including sonar. They measured the distance to the 160 dB threshold to be 130 m, resulting in an ensonified area of 0.053 km^2. We have provided both methods for NMFS consideration.

6.2.3 Ice Management

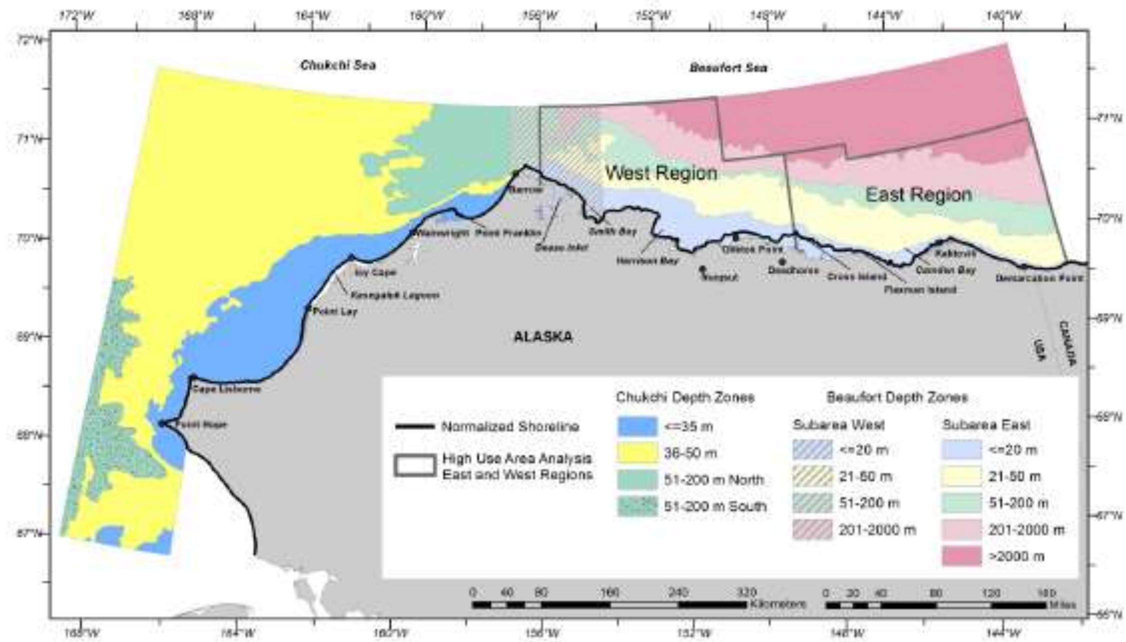
Although highly unlikely, it may be necessary for ice management near Point Barrow while transiting to the Sivulliq site. During exploration drilling operations on the Burger Prospect in 2012, encroachment of sea ice required the Discoverer to temporarily depart the drill site. While it was standing by to the south, ice management vessels remained at the drill site to protect buoys that were attached to the anchors. Sounds produced by vessels managing the ice were recorded and the distance to the 120 dB re 1 μPa rms threshold was calculated to occur at 9.6 km (JASCO et al. 2014). The total calculated ensonified area would be 290 km^2.

6.3 ESTIMATES OF MARINE MAMMAL DENSITY

The densities of marine mammals per species were calculated using 2009-2014 ASAMM data (http://www.afsc.noaa.gov/nmml/cetacean/bwasp/index.php) for bowhead, beluga, and gray whales in the Beaufort and Chukchi Seas and the Shell 2015 IHA application (Shell 2015) for all other species. The ASAMM density data are separated by depth, month, year, and location (**Error! Reference source not found.**). We utilized the maximum calculated density using the depth strata in which the anchor system is located, the month (based on project activity timing), year (maximum of 2009-2014), and location (Chukchi vs. Beaufort). For example, anchor handling only occurs in the summer, so density data from July and August were used; side scan sonar may occur at the beginning and end of the project, so density data were separated into summer and fall. The Shell 2015 IHA included average and maximum density estimates for area, month, and location. We utilized the maximum calculated density for these other species, regardless of area, month, or location.

The Kotzebue site is located within the 0-35 m south region, the Kakapo site is located within the 0-35 m north region, the Burger sites are located within the 35-50 m region, and the ice management activity would occur near Point Barrow in the 50-200 m north region in the Chukchi Sea. The Sivulliq site is located within the east 21-50 m region in the Beaufort Sea.

Figure 4. ASAMM Chukchi and Beaufort Sea Depth Zones.



6.3.1 Bowhead Whale

The bowhead whale density estimate is separated into the Chukchi Sea and Beaufort Seas based on the ASAMM study areas (**Error! Reference source not found.**) for aerial data collected 2008-2014. For each depth stratum, we used the maximum density estimate for summer and fall (Table 5). The bowhead whale densities in the Chukchi Sea range up to 0.0145 whales/km^2 in the summer and up to 0.1813 whales/km^2 in the fall, with the highest density for both seasons in the 50-200 m north region. The bowhead whale densities in the Beaufort Sea range up to 0.2883 whales/km^2 in the summer and up to 0.1310 whales/km^2 in the fall, both in the east 21-50 m region.

6.3.2 Beluga Whale

The beluga whale density estimate is separated into the Chukchi Sea and Beaufort Seas based on the ASAMM study areas (**Error! Reference source not found.**) for aerial data collected 2008-2014. For each depth stratum, we used the maximum density estimate for summer and fall (Table 5). The beluga whale densities in the Chukchi Sea range up to 0.1633 whales/km^2 in the summer in the 0-35 m north region and up to 0.0495 whales/km^2 in the fall in the 50-200 m north region. The beluga whale densities in the Beaufort Sea range up to 0.7924 whales/km^2 in the summer and up to 0.1425 whales/km^2 in the fall, both in the east 51-200 m east region.

6.3.3 Gray Whale

The gray whale density estimate is only in the Chukchi Sea based on the ASAMM study areas (**Error! Reference source not found.**) for aerial data collected 2008-2014. For each depth stratum, we used the maximum density estimate for summer and fall (Table 5). The gray whale densities in the Chukchi Sea range up to 0.2594 whales/km^2 in the summer and up to 0.1732 whales/km^2 in the fall, with the highest density for both seasons in the 50-200 m south region.

6.3.4 Other Cetaceans

Shell (2015) derived average and maximum density estimates for summer and fall from all available open water research and monitoring data. For the purposes of this project, we used the maximum of the density estimates provided, regardless of whether the density was for summer or fall (Table 6). The maximum density is 0.0044 whales/km^2 for the harbor porpoise; 0.0004 whales/km^2 for the fin, humpback, and killer whale; and 0.0006 whales/km^2 for the minke whale.

6.3.5 Seals

Shell (2015) derived average and maximum density estimates for summer and fall from all available open water research and monitoring data. For the purposes of this project, we used the maximum of the density estimates provided, regardless of whether the density was for summer or fall (Table 6). The maximum density is 0.6075 seals/km^2 for the ringed seal; 0.0203 seals/km^2 for the bearded seal; and 0.0122 seals/km^2 for the spotted seal.

Table 5. Summary of Expected Densities for Bowhead, Beluga, and Gray Whales

Depth Stratum	Bowhead whale		Beluga whale		Gray whale	
	Summer	Fall	Summer	Fall	Summer	Fall
Chukchi Sea						
0-35 m south	0.000	0.000	0.000	0.000	0.021	0.000
0-35 m north	0.008	0.015	0.163	0.005	0.032	0.002
35-50 m	0.003	0.051	0.003	0.035	0.014	0.008
50-200 m north	0.015	0.181	0.045	0.049	0.036	0.009
50-200 m south	0.000	0.029	0.000	0.000	0.259	0.0173
Beaufort Sea						
21-50 m east	0.288	0.131	0.108	0.004	NA	NA
51-200 m east	0.251	0.025	0.792	0.142	NA	NA

Table 6. Summary of Expected Densities for Other Species

Species	Density	Timing	Max
Ringed Seal	0.3668	Average Summer	0.6075
	0.6075	Highest Summer	
	0.2548	Average Fall	
	0.4070	Highest Fall	
Bearded Seal	0.0107	Average Summer	0.0203
	0.0203	Highest Summer	
	0.0107	Average Fall	
	0.0203	Highest Fall	
Spotted Seal	0.0073	Average Summer	0.0122
	0.0122	Highest Summer	
	0.0049	Average Fall	
	0.0081	Highest Fall	
Fin Whale	0.0001	Average Summer	0.0004
	0.0004	Highest Summer	
	0.0001	Average Fall	
	0.0004	Highest Fall	
Harbor Porpoise	0.0022	Average Summer	0.0044
	0.0029	Highest Summer	
	0.0021	Average Fall	
	0.0044	Highest Fall	
Humpback Whale	0.0001	Average Summer	0.0004
	0.0004	Highest Summer	
	0.0001	Average Fall	
	0.0004	Highest Fall	
Killer Whale	0.0001	Average Summer	0.0004
	0.0004	Highest Summer	
	0.0001	Average Fall	
	0.0004	Highest Fall	
Minke Whale	0.0003	Average Summer	0.0006
	0.0006	Highest Summer	
	0.0003	Average Fall	
	0.0006	Highest Fall	

6.4 ESTIMATING POTENTIAL EXPOSURE OF MARINE MAMMALS

The estimates of the numbers of each marine mammal species that could potentially be exposed to sound associated with the anchor retrieval program, specifically the unseating of anchors, potential side scan sonar survey, and potential ice management, were estimated using the methods described below. We multiplied the following three variables: 1) the area (in km^2) of ensonification for disturbance for each activity, 2) the duration (in days) of the sound activity, and 3) the density (# of marine mammals/ km^2) as summarized in Table 5 and Table 6. It is important to note that these estimates are based on worst-case (and unlikely) sound levels and duration, and the maximum reported density estimates that do not account for the movement of animals near the anchor site during retrieval activities. Therefore, these estimates are extremely conservative and highly unlikely. A summary of the total number of estimated exposures per species, per sea, and per season is provided in Table 7. The details for calculating exposure for the Chukchi Sea are provided in Table 8 and Table 9 for the Beaufort Sea.

6.4.1 Disturbance Ensonification Area

Anchor Handling: The area exceeding the 120 dB disturbance threshold for non-impulsive sound at each site was calculated using two methods:

- **Method 1:** In the 2012 Shell Comprehensive Joint Monitoring Report (LGL et al. 2014), JASCO measured anchor handling activity during 2012 exploration activities. The measured level was 143 dB re 1 µPa at 860 m. Assuming a simple spreading loss of 20 log R, the extrapolated distance to the 120 dB threshold would be 12,000 m. The area ensonified was then calculated (area of circle = ΠR^2), where R is 12,000 m. The total calculated ensonified area would be 452 km^2.
- **Method 2:** In the 2015 Shell IHA application (Shell 2015), JASCO modeled the anchor handling activity using their proprietary software with a resulting total area ensonified equaling 1,535 km^2.

Side Scan Survey: The area exceeding the 160 dB disturbance threshold for impulsive sound at each site was calculated using two methods:

- **Method 1:** Manufacturer specifications for single and multi-beam sonar provide a source level of 220 dB re 1 µPa at 1 m (Kongsberg 2014). Assuming a simple spreading loss of 20 log R, the extrapolated distance to the 160 dB threshold would be 1,000 m. The total calculated ensonified area would be 3.14 km^2.
- **Method 2:** In the 2013 Shell 90-day report for seismic activities (Reider et al. 2013), JASCO measured the distance of a side scan survey to the 160 dB threshold at 130 m. The total calculated ensonified area would be 0.053 km^2.

Ice Management: The area exceeding the 120 dB disturbance threshold for non-impulsive sound was calculated using the Shell 2012 90-day report (Austin et al. 2013). They reported the extrapolated distance to the 120 dB was 9,600 m. The total calculated ensonified area would be 290 km^2.

6.4.2 Duration of Sound Per Activity

Anchor Handling: Each anchor site has different configurations and numbers of anchors, but we assume it will take up to seven (7) days per site to remove all anchors. Because the vessels will not be operating at full power during the entire time, we assumed half of the time (3.5 days) will be utilizing the high power to unseat anchors. With five (5) anchor sites, this results in 17.5 days of anchor handling activity that may result in disturbance.

Side Scan Survey: The side scan sonar survey is expected to take up to three (3) days at each site and we assume the sonar will be operated 24 hours during that time, although it is unlikely it will be operating full time or that it will take three full days. Each anchor site will be surveyed in the summer prior to anchor handling for a total of 15 days in summer. Each anchor site may also be surveyed in the fall after retrieval activities for a total of 15 days in fall.

Ice Management: Although unlikely, we assume it will take place over a two (2) day period near Point Barrow.

Table 7. Summary of Number of Marine Mammals Potentially Exposed to Disturbance Sound Levels.

	Chukchi Sea		Beaufort Sea		Total		
Species	**Summer**	**Fall**	**Summer**	**Fall**	**Summer**	**Fall**	**Total**
Bowhead whale	80.81	1.11	1,551.35	1.23	1,632.16	2.34	1,634.51
Gray whale	461.87	0.17	0	0	461.87	0.17	462.03
Beluga whale	935.54	0.71	580.55	0.04	1,516.09	0.75	1,516.84
Ringed seal	13,429.86	22.90	3,269.52	5.73	16,699.37	28.63	16,728.00
Bearded seal	448.77	0.77	109.25	0.19	558.02	0.96	558.98
Spotted seal	269.70	0.46	65.66	0.11	335.36	0.57	335.94
Fin whale	8.84	0.02	2.15	0.00	11.00	0.02	11.01
Harbor porpoise	97.27	0.17	23.68	0.04	120.95	0.21	121.16
Humpback whale	8.84	0.02	2.15	0.00	11.00	0.02	11.01
Killer whale	8.84	0.02	2.15	0.00	11.00	0.02	11.01
Minke whale	13.26	0.02	3.23	0.01	16.49	0.03	16.52

Table 8. Summary of Potential Exposures for the Anchor Retrieval Program in the Chukchi Sea.

			Anchor Handling			Side Scan Sonar					Ice Management (1 vessel)			Total No. Exposed		
			120 dB Area (1,535 km²)			160 dB Area (3.14 km²)					120 dB Area (290 km²)					
Species	Density Estimate (mammals/km²)		No. of Days		No. Exposed	No. of Days		No. Exposed			No. of Days		No. Exposed			
Bowhead whale	**Summer**	**Fall**	**Summer**	**Fall**	**Summer**	**Summer**	**Fall**	**Summer**	**Fall**	**Total**	**Summer**	**Fall**	**Summer**	**Summer**	**Fall**	**Total**
0-35 m South (Kotz)	0.0000	0.0000	3.5	0.0	0.0	3.0	3.0	0.00	0.00	0.00	0.0	0.0	0.00			
0-35 m North (Kakapo)	0.0075	0.0148	3.5	0.0	40.5	3.0	3.0	0.07	0.14	0.21	0.0	0.0	0.00			
35-50 m (Burger)	0.0030	0.0514	7.0	0.0	31.7	6.0	6.0	0.06	0.97	1.03	0.0	0.0	0.00			
50 - 200 m North (Barrow)	0.0145	0.1813	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	2.0	0.0	8.42			
50 - 200 m South	0.0000	0.0286	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.0	0.0	0.00			
total					**72.3**			**0.13**	**1.11**	**1.24**			**8.42**	**80.81**	**1.11**	**81.92**
Gray whale																
0-35 m South (Kotz)	0.0206	0.0000	3.5	0.0	110.4	3.0	3.0	0.19	0.00	0.19	0.0	0.0	0.00			
0-35 m North (Kakapo)	0.0325	0.0025	3.5	0.0	174.6	3.0	3.0	0.31	0.02	0.33	0.0	0.0	0.00			
35-50 m (Burger)	0.0144	0.0075	7.0	0.0	155.2	6.0	.0	0.27	0.14	0.41	0.0	0.0	0.00			
50 - 200 m North (Barrow)	0.0360	0.0091	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	2.0	0.0	20.87			
50 - 200 m South	0.2594	0.1732	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.0	0.0	0.00			
total					**440.2**			**0.77**	**0.17**	**0.94**			**20.87**	**461.87**	**0.17**	**462.03**
Beluga whale																
0-35 m South (Kotz)	0.0000	0.0000	3.5	0.0	0.0	3.0	3.0	0.00	0.00	0.00	0.0	0.0	0.00			
0-35 m North (Kakapo)	0.1633	0.0046	3.5	0.0	877.4	3.0	3.0	1.54	0.04	1.58	0.0	0.0	0.00			
35-50 m (Burger)	0.0028	0.0353	7.0	0.0	30.5	6.0	6.0	0.05	0.67	0.72	0.0	0.0	0.00			
50 - 200 m North (Barrow)	0.0450	0.0495	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	2.0	0.0	26.07			
50 - 200 m South	0.0000	0.0000	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.0	0.0	0.00			
total					**907.9**			**1.59**	**0.71**	**2.30**			**26.07**	**935.54**	**0.71**	**936.25**
Ringed seal	0.6075	0.6075	14.0	0.0	13,055.2	12.0	12.0	22.90	22.90	45.80	2.0	0.0	351.78	13,429.86	22.90	13,452.76
Bearded seal	0.0203	0.0203	14.0	0.0	436.2	12.0	12.0	0.77	0.77	1.53	2.0	0.0	11.75	448.77	0.77	449.53
Spotted seal	0.0122	0.0122	14.0	0.0	262.2	12.0	12.0	0.46	0.46	0.92	2.0	0.0	7.06	269.70	0.46	270.16
Fin whale	0.0004	0.0004	14.0	0.0	8.6	12.0	12.0	0.02	0.02	0.03	2.0	0.0	0.23	8.84	0.02	8.86
Harbor porpoise	0.0044	0.0044	14.0	0.0	94.6	12.0	12.0	0.17	0.17	0.33	2.0	0.0	2.55	97.27	0.17	97.44
Humpback whale	0.0004	0.0004	14.0	0.0	8.6	12.0	12.0	0.02	0.02	0.03	2.0	0.0	0.23	8.84	0.02	8.86
Killer whale	0.0004	0.0004	14.0	0.0	8.6	12.0	12.0	0.02	0.02	0.03	2.0	0.0	0.23	8.84	0.02	8.86
Minke whale	0.0006	0.0006	14.0	0.0	12.9	12.0	12.0	0.02	0.02	0.05	2.0	0.0	0.35	13.26	0.02	13.29

Table 9. Summary of Potential Exposures for the Anchor Retrieval Program in the Beaufort Sea.

			Anchor Handling			Side Scan Sonar					Total No. Exposed		
			120 dB Area (1,535 km²)			160 dB Area (3.14 km²)							
Species	Density Estimate (mammals/km²)		No. of Days		No. Exposed	No. of Days		No. Exposed					
Bowhead whale	**Summer**	**Fall**	**Summer**	**Fall**	**Summer**	**Summer**	**Fall**	**Summer**	**Fall**	**Total**	**Summer**	**Fall**	**Total**
east 21-50 m (Sivulliq)	0.2883	0.1310	3.5	0.0	1,548.6	3.0	3.0	2.72	1.23	3.95			
east 51-200 m	0.2507	0.0249	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00			
total					**1,548.6**			**2.72**	**1.23**	**3.95**	**1,551.35**	**1.23**	**1,552.59**
Beluga whale													
east 21-50 m (Sivulliq)	0.1079	0.0044	3.5	0.0	579.5	3.0	3.0	1.02	0.04	1.06			
east 51-200 m	0.7924	0.1425	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00			
total					**579.5**			**1.02**	**0.04**	**1.06**	**580.55**	**0.04**	**580.59**
Ringed seal	0.6075	0.6075	3.5	0.0	3,263.8	3.0	3.0	5.73	5.73	11.45	3,269.52	5.73	3,275.24
Bearded seal	0.0203	0.0203	3.5	0.0	109.1	3.0	3.0	0.19	0.19	0.38	109.25	0.19	109.44
Spotted seal	0.0122	0.0122	3.5	0.0	65.5	3.0	3.0	0.11	0.11	0.23	65.66	0.11	65.77
Fin whale	0.0004	0.0004	3.5	0.0	2.1	3.0	3.0	0.00	0.00	0.01	2.15	0.00	2.16
Harbor porpoise	0.0044	0.0044	3.5	0.0	23.6	3.0	3.0	0.04	0.04	0.08	23.68	0.04	23.72
Humpback whale	0.0004	0.0004	3.5	0.0	2.1	3.0	3.0	0.00	0.00	0.01	2.15	0.00	2.16
Killer whale	0.0004	0.0004	3.5	0.0	2.1	3.0	3.0	0.00	0.00	0.01	2.15	0.00	2.16
Minke whale	0.0006	0.0006	3.5	0.0	3.2	3.0	3.0	0.01	0.01	0.01	3.23	0.01	3.23

a

7.0 DESCRIPTION OF IMPACT ON MARINE MAMMALS

The anticipated impact of the activity upon the species or stock.

7.1 GENERAL EFFECTS OF NOISE ON MARINE MAMMALS

Marine mammals use hearing and sound transmission to perform vital life functions. Introducing sound into their environment could be disrupting to those behaviors. Sound (hearing and vocalization/ echolocation) serves four primary functions for marine mammals, including: 1) providing information about their environment, 2) communication, 3) prey detection, and 4) predator detection. The distances to which vessel, ice management, and side scan sonar sound associated with the Anchor Retrieval Program are detectable by marine mammals depends on source levels, frequency, ambient noise levels, the propagation characteristics of the environment, and sensitivity of the receptor (Richardson et al. 1995b).

The effects of sounds from industrial activities such as anchor handling, ice management, and side scan sonar on marine mammals might include one or more of the following: tolerance, masking of natural sounds, behavioral disturbance, and temporary or permanent hearing impairment, or non-auditory physical effects (Richardson et al. 1995b). In assessing potential effects of noise, Richardson et al. (1995b) has suggested four criteria for defining zones of influence. These zones are described below from greatest influence to least:

Zone of hearing loss, discomfort, or injury – the area within which the received sound level is potentially high enough to cause discomfort or tissue damage to auditory or other systems. This includes temporary threshold shifts (TTS, temporary loss in hearing) or permanent threshold shifts (PTS, loss in hearing at specific frequencies or deafness). Non-auditory physiological effects or injuries that theoretically might occur in marine mammals exposed to strong underwater sound include stress, neurological effects, bubble formation, resonance effects, and other types of organ or tissue damage.

Zone of masking – the area within which the noise may interfere with detection of other sounds, including communication calls, prey sounds, or other environmental sounds.

Zone of responsiveness – the area within which the animal reacts behaviorally or physiologically. The behavioral responses of marine mammals to sound is dependent upon a number of factors, including: 1) acoustic characteristics of the noise source of interest; 2) physical and behavioral state of animals at time of exposure; 3) ambient acoustic and ecological characteristics of the environment; and 4) context of the sound (e.g., whether it sounds similar to a predator) (Richardson et al. 1995b; Southall et al. 2007). However, temporary behavioral effects are often simply evidence that an animal has heard a sound and may not indicate lasting consequence for exposed individuals (Southall et al. 2007).

Zone of audibility – the area within which the marine mammal might hear the noise. Marine mammals as a group have functional hearing ranges of 10 Hz to 180 kHz, with best thresholds near 40 dB (Ketten 1998; Kastak et al. 2005; Southall et al. 2007). These data show reasonably consistent patterns of hearing sensitivity within each of three groups: small odontocetes (such as the harbor porpoise), medium-sized odontocetes (such as the beluga and killer whales), and pinnipeds (such as the spotted, ringed, or bearded seals). There are no applicable criteria for the zone of audibility due to difficulties in human ability to determine the audibility of a particular noise for a particular species.

The following text describes the potential impacts on marine mammals due to the sources associated with this program. Due to relatively low sound levels and relatively short period of time over the entire season the louder activities will occur, and the mitigation measures discussed in Sections 11 and 14, it is unlikely there would be any temporary or especially permanent hearing impairment, or non-auditory physical effects on marine mammals.

7.2 POTENTIAL EFFECTS OF SOUND FROM ANCHOR RETRIEVAL PROGRAM

7.2.1 Tolerance

Studies have shown that underwater sounds from anthropogenic activities are often detectable underwater at distances of many kilometers away from the source(s). Studies have also shown that marine mammals at distances more than a few kilometers away often show no apparent response to various types of industry activities (Moulton et al. 2005; Harris et al. 2001; LGL et al. 2014). This is often true even in cases when the sounds are likely audible to the animals based on measured received levels and the hearing sensitivity of that mammal group. All marine mammals have exhibited some behavioral reaction to underwater industry sounds, but they have also exhibited no overt reactions to underwater sounds (Stone and Tasker 2006; Hartin et al. 2013). In general, pinnipeds and small odontocetes appear to be more tolerant of exposure to some types of underwater sound than are baleen whales. Based upon the above information regarding marine mammal tolerance to underwater sounds, FWS anticipates that some marine mammals exposed to the low levels of underwater sounds from anchor handling activities will show no response.

7.2.2 Masking

Masking occurs when louder anthropogenic sounds interfere with marine mammal vocalizations or ability to hear natural sounds in their environment (Richardson et al. 1995b), which limit their ability to communicate or avoid predation or other natural hazards. Given the small footprint of sound levels exceeding 160 dB for anchor handling and sonar, FWS expects no impacts related to masking in marine mammals.

Anchor handling or ice management activities have the potential to mask low frequency vocalizations of baleen whales if they are in close proximity to the vessels during anchor handling activities under high power, such as bowhead and gray whales. The timing of the anchor handling is designed to avoid timing of bowhead whale presence, so it is unlikely bowhead masking would occur. Gray whales are common in the Chukchi Sea, especially near Wainwright, but they are not as vocal and they do not have as low frequency calls as bowheads, so it is unlikely masking would occur for gray whales.

Side scan sonar activities have the potential to mask high frequency vocalizations of odontocetes, like beluga whales or harbor porpoises. The source level of 200 kHz of the sonar is above the known beluga and harbor porpoise hearing, but harmonics of the sonar may be audible. Beluga whales have a well-developed and well-documented sense of hearing between approximately 40 Hz to 130 kHz (White et al. 1978; Johnson et al. 1989; Ridgway et al. 200; Finneran et al. 2005). The harbor porpoise has the highest upper-frequency limit of all odontocetes investigated. Kastelein et al. (2002) found that the range of best hearing was from 16 to 140 kHz, with a reduced sensitivity around 64 kHz. Maximum sensitivity (about 33 dB re 1 µPa) occurred between 100 and 140 kHz. This maximum sensitivity range corresponds with the peak frequency of echolocation pulses produced by harbor porpoises (120–130 kHz).

Due to the small acoustic footprint of these activities, masking is likely to be minimal, if at all.

7.2.3 Behavioral Disturbance

Reactions to sound, if any, depend on species, state of maturity, experience, current activity, reproductive state, time of day, environmental conditions, and many other factors (Richardson et al. 1995b). If a marine mammal does react briefly to an underwater sound by changing its behavior or moving a short distance, the impacts of the change are unlikely to be significant to the individual, let alone the stock or the species as a whole. However, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, which is not anticipated in the proposed anchor retrieval program, impacts on the animals could be significant. Given the many uncertainties in predicting the quantity and types of impacts of sound on marine mammals, it is common practice to estimate how many mammals were present within a particular distance of industrial activities, or exposed to a particular level of industrial sound to assess behavioral disturbance. However, this procedure likely overestimates the numbers of marine mammals that are affected in some biologically important manner.

7.2.3.1 Baleen Whales

Southall et al. (2007 Appendix C) reviewed a number of papers describing the responses of marine mammals to non-pulsed sound. In general, little or no response was observed in animals exposed at received levels from 90-120 dB re 1 µPa rms. Probability of avoidance and other behavioral effects increased when received levels were 120-160 dB re 1 µPa rms. Some of the relevant reviews of Southall et al. (2007) are summarized below.

Brewer et al. (1993) and Hall et al. (1994) reported numerous sightings of marine mammals including bowhead whales in the vicinity of offshore drilling operations in the Beaufort Sea. One bowhead whale sighting was reported within ~400 m of a drilling vessel although most other bowhead sightings were at much greater distances. Few bowheads were recorded near industrial activities by aerial observers. After controlling for spatial autocorrelation in aerial survey data from Hall et al. (1994) using a Mantel test, Schick and Urban (2000) found that the variable describing straight line distance between the rig and bowhead whale sightings was not significant, but that a variable describing threshold distances between sightings and the rig was significant. Thus, although the aerial survey results suggested substantial avoidance of the operations by bowhead whales, observations by vessel-based observers indicate that at least some bowheads may have been closer to industrial activities than was suggested by results of aerial observations.

Richardson et al. (2008) reported a slight change in the distribution of bowhead whale calls in response to operational sounds on BP’s Northstar Island. The southern edge of the call distribution ranged from 0.76 to 2.35 km (0.47 to 1.46 mi) farther offshore, apparently in response to industrial sound levels. This result, however, was only achieved after intensive statistical analyses, and it is not clear that this represented a biologically material effect.

Malme et al. (1983, 1984) used playback of sound from helicopter overflight and drilling rigs and platforms to study behavioral effects on migrating gray whales. Received levels exceeding 120 dB re 1 µPa rms induced avoidance reactions. Malme et al. (1984) calculated 10, 50, and 90 percent probabilities of gray whale avoidance reactions at received levels of 110, 120, and 130 dB re 1 µPa rms, respectively.

Malme et al. (1986) observed the behavior of feeding gray whales during four experimental playbacks of drilling sounds (50 to 315 Hz; 21-minutes [min] overall duration and 10 percent duty cycle; source levels 156 to 162 dB re 1 µPa-m). In two cases for received levels of 100 to 110 dB re 1 µPa, no behavioral reaction was observed. Avoidance behavior was observed in two cases where received levels were 110 to 120 dB re 1 μPa rms.

Richardson et al. (1995) performed 12 playback experiments in which bowhead whales in the Alaskan Arctic were exposed to drilling sounds. Whales generally did not respond to exposures in the 100 to 130 dB re 1 μPa rms range, although there was some indication of behavioral changes in several instances.

Finally, Nowacek et al. (2004) used controlled exposures to demonstrate behavioral reactions of northern right whales to various nonplused sounds. Playback stimuli included ship noise, social sounds of conspecifics, and a complex, 18-min "alert" sound consisting of repetitions of three different artificial signals. Ten whales were tagged with calibrated instruments that measured received sound characteristics and concurrent animal movements in three dimensions. Five out of six exposed whales reacted strongly to alert signals at measured received levels between 130 and 150 dB re 1 μPa rms (i.e., ceased foraging and swam rapidly to the surface). Two of these individuals were not exposed to ship noise and the other four were exposed to both stimuli. These whales reacted mildly to conspecific signals. Seven whales, including the four exposed to the alert stimulus, had no measurable response to either ship sounds or actual vessel noise.

Based upon the above information regarding baleen whale disturbance reactions, FWS anticipates that some baleen whales may exhibit minor, short-term disturbance responses to underwater sounds from anchor handling activities. Any potential impacts on baleen whale behavior would be localized within the activity area and would not result in population-level effects.

7.2.3.2 Toothed Whales

Most toothed whales have the greatest hearing sensitivity at frequencies much higher than that of baleen whales and may be less responsive to low-frequency sound commonly associated with industry activities. Richardson et al. (1995a) reported that beluga whales did not show any apparent reaction to playback of underwater drilling sounds at distances greater than 200-400 m (656–1,312 ft). Reactions included slowing down, milling, or reversal of course after which the whales continued past the projector, sometimes within 50-100 m (164-328 ft). The authors concluded (based on a small sample size) that playback of drilling sound had no biological effects on migration routes of beluga whales migrating through pack ice and along the seaward side of the nearshore lead east of Point Barrow in spring.

At least six of 17 groups of beluga whales appeared to alter their migration path in response to underwater playbacks of icebreaker sound (Richardson et al. 1995b). Received levels from the icebreaker playback were estimated at 78-84 dB re 1 μPa rms in the 1/3-octave band centered at 5,000 Hz, or 8-14 dB re 1 μPa rms above ambient. If beluga whales reacted to an actual icebreaker at received levels of 80 dB, reactions would be expected to occur at distances on the order of 10 km (6 mi). Finley et al. (1990) also reported beluga avoidance of icebreaker activities in the Canadian High Arctic at distances of 35 to 50 km (22 to 31 mi). In addition to avoidance, changes in dive behavior and pod integrity were also noted. Beluga whales have also been reported to avoid active seismic vessels at distances of 10-19 km (6-12 mi) (Miller et al. 2005). It is likely that at least some beluga whales may avoid the vicinity of the proposed activities thus reducing the potential for exposure to high levels of underwater sound.

In reviewing responses of cetaceans with best hearing in mid-frequency ranges, which includes toothed whales, Southall et al. (2007) reported that combined field and laboratory data for mid-frequency cetaceans exposed to nonplused sounds did not lead to a clear conclusion about received levels coincident with various behavioral responses. In some settings, individuals in the field showed profound behavioral responses to exposures from 90 to 120 dB re 1 μPa rms, while others failed to exhibit such responses for exposure to received levels from 120 to 150 dB re 1 μPa rms. Contextual variables other than exposure received level, and probable species differences, are the likely reasons for this variability. Context, including the fact that captive subjects were often directly reinforced with food for tolerating noise exposure, may also explain why there was great disparity in results from field and laboratory conditions - exposures in captive settings generally exceeded 170 dB re 1 μPa rms before inducing behavioral responses. Below we summarize some of the relevant material reviewed by Southall et al. (2007).

LGL and Greeneridge (1986) and Finley et al. (1990) documented belugas and narwhals congregated near ice edges reacting to the approach and passage of icebreaking ships. Beluga whales responded to oncoming vessels by; (1) fleeing at speeds of up to 20 kilometers per hour (km/hr) from distances of 19 to 80 km (12 to 50 mi), (2) abandoning normal pod structure, and (3) modifying vocal behavior and/or emitting alarm calls. Narwhals, in contrast, generally demonstrated a "freeze" response, lying motionless or swimming slowly away (as far as 23 mi/37 km down the ice edge), huddling in groups, and ceasing sound production. There was some evidence of habituation and reduced avoidance 2 to 3 days after onset.

Finally, two papers deal with important issues related to changes in marine mammal vocal behavior as a function of variable background noise levels. Foote et al. (2004) found increases in the duration of killer whale calls over the period 1977 to 2003, during which time vessel traffic in Puget Sound, and particularly whale-watching boats around the animals, increased dramatically. Scheifele et al. (2005) demonstrated that belugas in the St. Lawrence River increased the levels of their vocalizations as a function of the background noise level (the "Lombard Effect").

Based upon the above information regarding toothed whale disturbance reactions, FWS anticipates that some toothed whales may exhibit minor, short-term disturbance responses to underwater sounds from anchor handling and sonar activities. Any potential impacts on toothed whale behavior would be localized within the activity area and would not result in population-level effects.

7.2.3.3 Pinnipeds

Pinnipeds generally seem to be less responsive to exposure to industrial sound than most cetaceans. Pinniped responses to underwater sound from some types of industrial activities such as seismic exploration appear to be temporary and localized (Harris et al. 2001; Reiser et al. 2009b).

Blackwell et al. (2004) reported little or no reaction of ringed seals in response to pile-driving activities during construction of a man-made island in the Beaufort Sea. Ringed seals were observed swimming as close as 46 m (150 ft) from the island and may have been habituated to the sounds which were likely audible at distances <3.0 km (<1.9 mi) underwater and 0.5 km (0.3 mi) in air. Moulton et al. (2005) reported that ringed seal densities on ice in the vicinity of a man-made island in the Beaufort Sea did not change materially before and after construction and drilling activities.

Southall et al. (2007) reviewed literature describing responses of pinnipeds to non-pulsed sound and reported that the limited data suggest exposures between ~90 and 140 dB re 1 μPa rms generally do not appear to induce strong behavioral responses in pinnipeds exposed to nonplused sounds in water; no data exist regarding exposures at higher levels. It is important to note that among these studies of pinnipeds responding to nonplused exposures in water, there are some apparent differences in responses between field and laboratory conditions. In contrast to the mid-frequency odontocetes, captive pinnipeds responded more strongly at lower levels than did animals in the field. Again, contextual issues are the likely cause of this difference.

Based upon the above information regarding pinniped disturbance reactions, FWS anticipates that some pinnipeds may exhibit minor, short-term disturbance responses to underwater sounds from anchor handling and sonar activities. Any potential impacts on pinniped behavior would be localized within the activity area and would not result in population-level effects.

7.2.3.4 Hearing Impairment and Other Physical Effects

Temporary or permanent hearing impairment is a possibility when marine mammals are exposed to very strong sounds. Current NMFS policy regarding exposure of marine mammals to high-level sounds is that cetaceans and pinnipeds should not be exposed to pulsed sounds exceeding 180 and 190 dB re 1 μPa rms, respectively (NMFS 2000). Those criteria have been used in defining the safety (shut down) radii during seismic survey activities in the Arctic in recent years. However, those criteria were established before there was data on the minimum received levels of sounds necessary to cause temporary auditory impairment in marine mammals.

NMFS is presently developing new noise exposure criteria for marine mammals that account for the now-available scientific data on TTS and other relevant factors in marine and terrestrial mammals (NMFS 2005; D. Wieting in Orenstein et al. 2004). New science-based noise exposure criteria are also proposed by a group of experts in this field, based on an extensive review and syntheses of available data on the effect of noise on marine mammals (Southall et al. 2007) and this review seems to confirm that the current 180 dB re 1 μPa rms and 190 dB re 1 μPa rms are conservative.

Several aspects of the planned monitoring and mitigation measures for this project are designed to detect marine mammals occurring near the anchor handling activities to avoid exposing them to underwater sound levels that might, at least in theory, cause hearing impairment. In addition, many cetaceans are likely to show some avoidance of the proposed activities. In those cases, the avoidance responses of the animals themselves will reduce or (most likely) avoid any possibility of hearing impairment.

Non-auditory physical effects might also occur in marine mammals exposed to strong underwater sound. Possible types of non-auditory physiological effects or injuries that theoretically might occur in mammals close to a strong sound source include stress, neurological effects, bubble formation, and other types of organ or tissue damage. It is possible that some marine mammal species (i.e., beaked whales) may be especially susceptible to injury and/or stranding when exposed to strong pulsed sounds. However, as discussed below, there is no definitive evidence that any of these effects occur even for marine mammals in close proximity to industrial sound sources and beaked whales do not occur in the proposed study area. It is unlikely that any effects of these types would occur during the proposed project given the brief duration of exposure of any given mammal, and the planned monitoring and mitigation measures.

Available data on the potential for underwater sounds from industrial activities to cause auditory impairment or other physical effects in marine mammals suggest that such effects, if they occur at all, would be temporary and limited to short distances. Marine mammals that show behavioral avoidance of the proposed activities, including most baleen whales, some odontocetes (including belugas), and some pinnipeds, are especially unlikely to incur auditory impairment or other physical effects. Animals exposed to intense sound may experience reduced hearing sensitivity for some period of time following exposure. This increased hearing threshold is known as noise induced threshold shift (TS). The amount of TS incurred in the animal is influenced by a number of noise exposure characteristics, such as amplitude, duration, frequency content, temporal pattern, and energy distribution (Kryter 1985; Richardson et al. 1995b; Southall et al. 2007). It is also influenced by characteristics of the animal, such as behavior, age, history of noise exposure, and health. The magnitude of TS generally decreases over time after noise exposure and if it eventually returns to zero, it is known as temporary threshold shift (TTS). If TS does not return to zero after some time (generally on the order of weeks), it is known as permanent threshold shift (PTS). Temporary threshold shift is not considered to be auditory injury and does not constitute 'Level A Harassment' as defined by the MMPA. Sound levels associated with TTS onset are generally considered to be below the levels that will cause PTS, which is considered to be auditory injury. For more information on TTS and PTS, please refer to NMFS Acoustic Criteria for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing. Underwater Acoustic Threshold Levels for Onset of Permanent and Temporary Threshold Shifts (USDOI, NOAA, 2015).

7.2.4 Strandings and Mortality

Marine mammal stranding or mortality would be highly unlikely to result from any of the proposed activities. Marine mammal strandings have been correlated with pulsed sounds produced during previous marine survey activities. Most of these events, however, involved beaked whales, which do not occur in the Chukchi Sea. Underwater sounds from vessel noise and anchor handling are less energetic and have slower rise times, and there is no evidence that they can cause serious injury, death, or stranding.

The most likely potential cause of mortality to marine mammals from the proposed activities would be a ship strike, and there have been no such strikes documented during oil and gas exploration activities in the Alaskan Arctic. Trained observers aboard project vessels are authorized to request mitigation measures, including reduction in vessel speed and course alteration, to minimize potential ship strikes. Given the above information, it is extremely unlikely that the proposed activities would result in stranding or mortality to marine mammals.

8.0 DESCRIPTION OF IMPACT ON SUBSISTENCE USES

The anticipated impact of the activity on the availability of the species or stocks of marine mammals for subsistence uses.

Subsistence hunting is an essential aspect of Iñupiat life, especially in rural coastal villages. The Iñupiat participate in subsistence hunting activities in and around the Chukchi and Beaufort Seas. The animals taken for subsistence provide a significant portion of the food that will last the community through the year. Marine mammals represent on the order of 60-80 percent of the total subsistence harvest. Along with the nourishment necessary for survival, the subsistence activities strengthen bonds within the culture, provide a means for educating the younger generation, provide supplies for artistic expression, and allow for important celebratory events.

The MMPA requires that any harassment not result in an unmitigable adverse impact on the availability of species or stocks for taking (101(a)(5)(D)(i)(II)). Unmitigable adverse impact is defined as (50 CFR 216.103):

- An impact resulting from the specified activity that is likely to reduce the availability of the species to a level insufficient for a harvest to meet subsistence needs by:
- Causing marine mammals to abandon or avoid hunting areas;
- Directly displacing subsistence users; or,
- Placing physical barriers between the marine mammals and the subsistence users; AND
- Cannot be sufficiently mitigated by other measures to increase the availability of marine mammals to allow subsistence needs to be met.

As described throughout this document, the planned anchor handling program may result in Level B harassment of marine mammal species or stocks. However, our analysis supports the conclusion that any harassment will not have an unmitigable adverse impact on the availability of such species or stock for taking for subsistence uses. In the following sub-sections, the major animals used for subsistence by villages of the upper-west and north coast of Alaska are discussed (bowhead whale, beluga whale, and all three common species of seals [ringed, spotted, and bearded seals]). All pinnipeds (seals) are discussed in one section.

8.1 BOWHEAD WHALE

As noted above in Section 7, monitoring studies (Davis 1987; Brewer et al. 1993; Hall et al. 1994) have documented temporary diversions in the swim path of migrating bowheads near drill sites; however, the whales have generally been observed to resume their initial migratory route within a distance of 10-32 km (6-20 mi). Drilling noise has not been shown to block or impede migration even in narrow ice leads (Davis 1987; Richardson et al. 1991).

Behavioral effects on bowhead whales from sound energy produced by industry activities, such as avoidance, deflection, and changes in surface/dive ratios, have generally been found to be limited areas around the drill site that are ensonified to >160 dB re 1 μPa rms, although effects have infrequently been observed out as far as areas ensonified to 120 dB re 1 μPa rms.

Anchor handling-related vessel traffic may traverse some areas used during bowhead harvests by Chukchi and Beaufort villages. Bowhead hunts by residents of Wainwright, Point Hope, and Point Lay take place almost exclusively in the spring prior to the date on which the vessels would commence the proposed anchor handling program. From 1984 through 2009, all bowhead harvests by these Chukchi Sea villages occurred only between April 14 and June 24 (George and Tarpley 1986; George et al. 1987, 1988, 1990, 1992, 1995, 1998, 1999, 2000; Philo et al. 1994; Suydam et al. 1995a,b, 1996, 1997, 2001a,b, 2002, 2003, 2004, 2005a,b, 2006, 2007, 2008, 2009, 2010), while vessels will not enter the Bering Sea (northbound) prior to July 1. However, fall whaling by some of these Chukchi Sea villages has occurred since 2010 and is likely to occur in the future, particularly if bowhead quotas are not completely filled during the spring hunt, and fall weather is accommodating. A Wainwright whaling crew harvested the first fall bowhead for these villages in 90 years or more on October 7, 2010, and another in October of 2011 (Suydam et al. 2011, 2012, 2013). No bowhead whales were harvested during fall in 2012, but 3 were harvested by Wainwright in fall 2013.

Barrow crews have traditionally hunted bowheads during both spring and fall; however, spring whaling by Barrow crews is normally finished before the date on which anchor handling operations would commence. From 1984 through 2011 whales were harvested in the spring by Barrow crews only between April 23 and June 15 (George and Tarpley 1986; George et al. 1987, 1988, 1990, 1992, 1995, 1998, 1999, 2000; Philo et al. 1994; Suydam et al. 1995 a, b, 1996, 1997, 2001a, 2002, 2003, 2004, 2005a,b, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013). Fall whaling by Barrow crews does take place during the time period when anchor handling activities would be completed, with vessels out of the Chukchi Sea by the end of August. From 1984 through 2011, whales were harvested in the fall by Barrow crews between August 31 and October 30, indicating that there is potential for vessel traffic to affect these hunts. Most fall whaling by Barrow crews, however, takes place east of Barrow along the Beaufort Sea coast therefore providing little opportunity for the anchor handling program to affect them. For example, Suydam et al. (2008) reported that in the previous 35 years, Barrow whaling crews harvested almost all their whales in the Beaufort Sea to the east of Point Barrow. As all anchor sites are over 100 miles from Barrow, we do not anticipate any conflict with Barrow harvest. In the event the sonar survey for Sivulliq is taking place as Barrow is harvesting, the *Norseman II* will traverse 50 mi offshore around Barrow, as we have for the last eight years.

Nuiqsut and Kaktovik crews traditionally hunt during the fall, harvesting in late August through September. The Alaska Eskimo Whaling Commission (AEWC) requires that all industry activities cease working east of 150° W by August 25th for the start of whaling for those communities. The anchor handling vessels will enter the Beaufort Sea as soon as ice at Point Barrow allows for safe passage and will complete the Sivulliq anchor retrieval well before August 25th. If a sonar survey is required on this site, it will take place after the completion of the fall hunt and has been cleared by both communities.

FWS's mitigation measures, which include a system of PSOs and communication with Com Centers in the respective region, will be implemented to avoid any effects from vessel traffic on fall whaling. Vessel movements are adjusted as needed and planned in a manner that avoids potential impacts to bowhead whale hunts and other subsistence activities. With these mitigation measures and the nature of our proposed action, we are confident that any harassment of bowhead whales resulting from the 2016 anchor handling program will not have an unmitigable adverse impact on the availability of this stock to be taken for subsistence uses.

8.2 BELUGA WHALE

Beluga whales typically do not represent a large proportion of the subsistence harvests by weight in the communities of Wainwright and Barrow, the nearest communities to the planned anchor handling project area. Barrow residents hunt beluga in the spring (normally after the bowhead hunt) in leads between Point

Barrow and Skull Cliffs in the Chukchi Sea, primarily in April-June and later in the summer (July-August) on both sides of the barrier island in Elson Lagoon/Beaufort Sea (Minerals Management Service [MMS] 2008), but harvest rates indicate the hunts are not frequent. Wainwright residents hunt beluga in April-June in the spring lead system, but this hunt typically occurs only if there are no bowheads in the area. Communal hunts for beluga are conducted along the coastal lagoon system later in July-August.

Belugas typically represent a much greater proportion of the subsistence harvest in Kotzebue, Point Lay, and Point Hope. Point Lay's primary beluga hunt occurs from mid-June through mid-July, but can sometimes continue into August if early success is not sufficient. Point Hope residents hunt beluga primarily in the lead system during the spring (late March to early June), but also in open water along the coastline in July and August. Belugas are harvested in spring mid-June through mid-July in Kotzebue, but the timing can vary based on beluga movement. Belugas are harvested in coastal waters near these villages, generally within a few miles from shore. In the Chukchi, the anchor retrieval sites are located more than 60 mi (97 km) offshore, therefore proposed anchor handling in the project area would have no or minimal impacts on beluga hunts.

The retrieval of anchors around Kotzebue is located nearshore and has the most potential for disturbance to beluga harvest. Communications with the Kotzebue Whaling Commission, AEWC, and Com Center (if established) will be imperative during operations in this area to avoid any conflict. Vessels will move offshore if we are not cleared to conduct activities.

Disturbance associated with vessel traffic could potentially affect beluga hunts. However, all of the beluga hunt by Barrow residents in the Chukchi Sea, and much of the hunt by Wainwright residents would likely be completed before anchor handling activities would commence. Additionally, vessel traffic associated with the anchor handling program will be restricted under normal conditions to designated corridors that remain onshore or proceed directly offshore thereby minimizing the amount of traffic in coastal waters where beluga hunts take place. The designated vessel traffic corridors do not traverse areas indicated in recent mapping as utilized by Point Lay or Point Hope for beluga hunts, and avoids important beluga hunting areas in Kasegaluk Lagoon that are used by Wainwright.

FWS has developed, and proposes to implement, a number of mitigation measures, e.g., PSOs on board vessels and the Com Center programs to ensure that there is no impact on the availability of the beluga whale as a subsistence resource. With these mitigation measures and the nature of the proposed action, we are confident that any harassment of beluga whales resulting from the 2016 anchor handling program will not have an unmitigable adverse impact on the availability of this stock to be taken for subsistence uses.

8.3 SEALS

Seals are an important subsistence resource and ringed seals make up the bulk of the seal harvest. Most ringed and bearded seals are harvested in the winter or in the spring before the anchor handling program would commence, but some harvest continues during open water and could possibly be affected by the planned activities. Spotted seals are also harvested during the summer. Most seals are harvested in coastal waters, with available maps of recent and past subsistence use areas indicating seal harvests have occurred only within 48-64 km (30-40 mi) of the coastline. The anchor handling retrieval sites are located more than 103 km (64 mi) offshore, so activities are thought to possibly have an impact on subsistence hunting for seals. Since most seal hunting is done during the winter and spring when the anchor handling program is not operational, potential effects to seal species are thought to be negligible. Mitigation measures to be implemented by FWS include participation in operational Com Centers as described below in Section 12.

With these mitigation measures and the nature of the proposed action, we are confident that any harassment of seals resulting from the 2016 anchor handling program will not have an unmitigable adverse impact on the availability of seals to be taken for subsistence uses.

9.0 DESCRIPTION OF IMPACT ON MARINE MAMMAL HABITAT

The anticipated impact of the activity upon the habitat of the marine mammal populations, and the likelihood of restoration of the affected habitat.

The planned anchor handling program will not result in any permanent impact on habitats used by marine mammals, or to their prey sources. The primary potential impacts to habitat expected are associated with elevated sound levels from anchor handling operations and its support vessels that result in marine mammals avoiding the area. These effects on marine mammal habitat from the generation of underwater sound from the planned anchor handling program are expected to be negligible and temporary, lasting only as long as the activity is on-going. A very small area of seafloor will be disturbed through the retrieval of anchors. This disturbance would include benthic habitat which would be altered in these areas, resulting in an indirect effect on benthic feeding marine mammals. All such effects would be negligible as only a very small portion of the available habitat would be affected and because the area would soon be re-colonized by benthic organisms.

This section identifies potential impacts to habitat, discusses the effect of each impact on marine mammals and threatened and endangered species, and then discusses the effect of the impact on primary food types, as applicable.

9.1 POTENTIAL IMPACTS ON HABITAT FROM SEAFLOOR DISTURBANCE (ANCHOR RETRIEVAL)

Retrieving of the anchors will result in some seafloor disturbance and temporary increases in water column turbidity. Previous drilling units were held in place during operations with systems of six-eight anchors for each unit. The embedment type anchors were designed to embed into the seafloor thereby providing the required resistance. The anchors generally penetrated the seafloor on contact. Both the anchor and anchor chain will disturb sediments during the retrieval process, creating a trench or depression with surrounding berms where the displaced sediment is mounded. Some sediment will be suspended in the water column during the removal of the anchors. The depression with associated berm, collectively known as an anchor scar, remains when the anchor is removed. Shell estimated that each anchor would impact a seafloor area of up to about 233 m^2 (2,510 ft^2). We assume the retrieval process will result in disturbance of this area, but the anchors will be removed and the area will most likely be recolonized.

Over time the anchor scars will be filled due to natural movement of sediment. The duration of the scars depends upon the energy of the system, water depth, ice scour, and sediment type. Anchor scars were visible under low energy conditions in the North Sea for five to ten years after retrieval. Scars typically do not form or persist in sandy mud or sand sediments but may last for nine years in hard clays (Centaur Associates, Inc. 1984). The energy regime, plus possible effects of ice gouge in the Arctic Ocean, suggests that anchor scars will be refilled faster than in the North Sea.

9.2 POTENTIAL IMPACTS ON FOOD SOURCES FROM SOUND GENERATION

9.2.1 Zooplankton

Zooplankton is a food sources for several endangered species, including bowhead, fin, and humpback whales. The primary generators of sound energy associated with the anchor handling program are the sonar, the retrieval of the anchors, and vessels. Sound energy generated by these activities will not negatively impact the diversity and abundance of zooplankton, and will therefore have no direct effect on marine mammals.

Studies on euphausiids and copepods, which are some of the more abundant and biologically important groups of zooplankton in the Chukchi Sea, have documented the use of hearing receptors to maintain schooling structures (Wiese 1996) and detection of predators (Hartline et al. 1996; Wong 1996) respectively, and therefore have some sensitivity to sound.

No appreciable adverse impact on zooplankton populations will occur due in part to large reproductive capacities and naturally high levels of predation and mortality of these populations. Any mortality or impacts on zooplankton as a result of the anchor handling program is immaterial as compared to the naturally-occurring reproductive and mortality rates of these species. This is consistent with previous conclusions that crustaceans (such as zooplankton) are not particularly sensitive to sound produced by seismic sounds (Wiese 1996). Impact from sound energy generated by vessels will most likely have less impact, as these activities produce lower sound energy levels (Burns et al. 1993). In conclusion, zooplankton organisms will not likely be affected by sound energy levels by the vessels to be used during anchor handling activities in the project area.

9.3 BENTHOS

There was no indication from benthic biomass or density that previous drilling activities at the Hammerhead Prospect have had a measurable impact on the ecology of the immediate local area. To the contrary, the abundance of benthic communities in the Sivulliq area would suggest that the benthos is actually thriving there (Dunton et al. 2008).

The primary generators of sound energy are the retrieval of the anchors, a potential sonar survey of the seafloor, and the anchor handling vessels. The low level of sound produced by the vessels will have negligible impacts on bottom-dwelling organisms, as will side scan sonar.

No appreciable adverse impacts on benthic populations would be expected due in part to large reproductive capacities and naturally high levels of predation and mortality of these populations. Any mortalities or impacts that might occur as a result of anchor handling operations is negligible compared to the naturally occurring high reproductive and mortality rates. This is consistent with previous BOEM conclusions which state that the effect of seismic exploration, and assumed sonar surveys, on benthic organisms probably would be immeasurable (MMS 2007). Impacts from sound energy generated by vessels will have less impact, as these activities produce much lower sound energy levels (Burns et al. 1993).

9.4 FISH

In general, fish perceive underwater sounds in the frequency range of 50 to 2,000 Hz, with peak sensitivities below 800 Hz (Popper and Carlson 1998; Department of the Navy 2001). However, fish are sensitive to underwater impulsive sounds due to swim bladder resonance. As the pressure wave passes through a fish, the swim bladder is rapidly squeezed as the high pressure wave, and then under pressure component of the wave, passes through the fish. The swim bladder may repeatedly expand and contract at the high sound pressure levels (SPL), creating pressure on the internal organs surrounding the swim bladder.

Permanent injury to fish from acoustic emissions has been shown for high-intensity sounds of several hours long. In a review on the effects of low-frequency noise to fish, a threshold of 180 dB peak sound level was used to define the potential injury to fish (NMFS 2011). Sound pressure levels greater than an average of

150 dB rms are expected to cause temporary behavioral changes such as a startle response or behaviors associated with stress. Although these SPLs are not expected to cause direct injury to a fish, they may decrease the ability of a fish to avoid predators.

Hastings and Popper (2005) reviewed all pertinent peer-reviewed and unpublished papers on noise exposure of fish through early 2005. They proposed the use of sound exposure level (SEL) to replace peak SPL in pile driving criteria. This report identified interim thresholds based on SEL or sound energy. The interim thresholds for injury were based on exposure to a single pile driving pulse. The report also indicates that there was insufficient evidence to make any findings regarding behavioral effects associated with these types of sounds. Interim thresholds were identified for pile driving consisting of a single-strike peak sound pressure and a single strike SEL for onset of physical injury. A peak pressure criterion was retained to function in concert with the SEL value for protecting fishes from potentially damaging aspects of acoustic impact stimuli. The available scientific evidence suggested that a single-strike peak pressure of 208 dB and a single strike SEL of 187 dB were appropriate thresholds for the onset of physical injury to fishes.

Only a small fraction of the potentially available habitat in the project area would be impacted by noise from the 2016 anchor handling activities at any given time. Furthermore, the constant movement of the vessel and the short duration of a potential actual sonar activity would result in, at most, a short-term, temporary, and very localized acoustic impact on fish and other prey species. Thus, the anchor handling program is not expected to have any effects on habitat or prey that could cause permanent or long-term consequences for marine mammals.

10.0 DESCRIPTION OF IMPACT FROM LOSS OR MODIFICATION TO HABITAT

The anticipated impact of the loss or modification of habitat on the marine mammal populations involved.

10.1 POTENTIAL IMPACTS ON HABITAT FROM VESSEL PRESENCE

The lengths of the vessels are not large enough to cause large-scale diversions from the animals' normal swim and migratory paths. There are no physical footprints of the vessels and therefore they would not cause marine mammals to deflect greatly from their typical migratory routes.

Any deflection of marine mammal species due to the physical presence of the vessels would be small. Even if animals may deflect because of the presence of the vessels, the Chukchi Sea's migratory corridor is much larger in size than the length of the vessels, and animals would have other means of passage around the anchor handling vessels. In sum, the physical presence of the vessels is not likely to cause a material deflection to migrating marine mammals. Moreover, any impacts would last only as long as the vessels are actually retrieving anchors. The anchor handling area covers a small percentage of the potentially available habitat used by marine mammals in the Arctic allowing marine mammals to move away from any generated sounds to feed, rest, migrate, or conduct other elements of their life history. Thus, the proposed activity is not expected to have any habitat-related effects that could cause significant or long-term consequences for individual marine mammals or their populations, since operations will be limited in duration, location, timing, and intensity.

11.0 MEASURES TO REDUCE IMPACTS TO MARINE MAMMALS

The availability and feasibility [economic and technological] of equipment, methods, and manner of conducting such activity or other means of effecting the least practicable adverse impact upon the affected species or stocks, their habitat, and on their availability for subsistence uses, paying particular attention to rookeries, mating grounds, and areas of similar significance.

The primary marine mammal species potentially exposed to underwater sounds during the proposed anchor handling program will be bowhead whales, gray whales, beluga whales, and the three species of seals. The following text describes the proposed measures to minimize takes by harassment. Reporting of data collected as part of the anchor handling program is discussed in more detail in Section 13. Additional monitoring guidelines can be found in FWS's marine mammal monitoring and mitigation plan (4MP) in Appendix A.

11.1 VESSEL-BASED MONITORING

Vessel-based NMFS-approved PSOs will monitor for marine mammals during vessel operations (including anchor handling) during all daytime hours. Vessel-based marine mammal monitoring and mitigation methods were designed to meet the requirements and objectives specified in this IHA and any LOA potentially obtained as a result of this program. The main purposes of PSOs aboard the vessels are to conduct visual watches for marine mammals to serve as the basis for implementation of mitigation measures, document numbers of marine mammals present, record any reactions of marine mammals to anchor-handling related activities, and identify whether there was any possible effect on accessibility of marine mammals to subsistence hunters in northern Alaska. These observations will provide the real-time data needed to implement some of the key measures.

For this program, it is not feasible to implement a power down or shut down procedure because once the anchor has been connected to the winch, stopping or even slowing the retrieval process could have major safety consequences. Accordingly, once the anchor is connected, we will not be able to stop operations if a marine mammal enters the zone. The PSOs will observe for marine mammals out to the horizon; detectability will depend on environmental conditions, height on vessel, distance of the marine mammal, and species. It is not feasible to visually monitor from the vessel to the 120 dB Level B safety zone for the anchor handling (12,000 m) because of the distance, but it is feasible to monitor the 160 dB Level B safety zone for both activities. Because the Level A zone is so small, we are electing to monitor the 160 dB zone instead.

The specific objectives of the vessel-based program provide:

- the basis for real-time mitigation, as required by the various permits,
- information needed to estimate the number of "takes" of marine mammals by harassment, which must be reported to NMFS and USFWS,
- data on the occurrence, distribution, and activities of marine mammals in the areas where the program was conducted,
- information to compare the distances, distributions, behaviors, and movements of marine mammals relative to the anchor handling activities, and
- a communication channel to coastal subsistence communities, including Iñupiat whalers.

Once on an anchor site, the vessels will work 24 hours a day to efficiently remove all anchors. During this time period (July and August), there is minimal nighttime. PSOs will monitor as long as daylight conditions allow. Vessel captain and crew will watch for marine mammals (insofar as practical at night) and will utilize the same procedures outlined in Section 11.2 below prior to anchor retrieval.

11.1.1 NMFS Acoustic Thresholds

Under current NMFS guidelines (e.g., NMFS 2000), acoustic thresholds for injury (exclusion zone) are defined as the distances within which received levels exceed 180 dB threshold for cetaceans and 190 dB threshold for pinnipeds. The 180 dB and 190 dB thresholds guidelines are also employed by USFWS for Pacific walrus and polar bear. Acoustic thresholds for harassment (safety zone) are defined as 160 dB for impulsive sounds and 120 dB for non-impulsive sounds for all marine mammals.

Using the same methods discussed in Section 6, the distances to the acoustic thresholds are provided in Table 10 and in the text below:

1) The distances to the thresholds for anchor handling activity at each site were calculated using Method 2 as described in Section 6 in the IHA application, per NMFS instructions. This method uses the modeled ensonified area of 1,535 km^2 from the 2015 Shell IHA application (Shell 2015). The IHA application or associated 4MP does not provide the distances to the zones specifically for anchor handling activities, but assuming a simple spreading loss of 20 log R, the extrapolated distances to the thresholds are provided in Table 10. Because distances to the exclusion zones for anchor handling and ice management are so close to the vessel, we propose to use the 160 dB safety zone of 100 m as a monitoring zone for all marine mammals. Although both methods require extrapolation to the 120 dB, this is the worst-case estimate and therefore most conservative.
2) The distances to the thresholds for side scan sonar activity were calculated using Method 1 as described in Section 6, per NMFS instructions. Manufacturer specifications for single and multi-beam sonar provide a source level of 220 dB re 1 µPa at 1 m (Teledyne Benthos Geophysical 2008; Konsberg 2014). Assuming a simple spreading loss of 20 log R, the extrapolated distances are provided in Table 10. Even though the side scan sonar is above 200 kHz and not typically regulated by NMFS (Shane Guan, personal communication), we will implement a shut down if a marine mammal enters the 180 dB exclusion zone of 100 m. We will monitor the 160 dB safety zone of 1000 m for behavioral responses.

Table 10. Distance to NMFS Thresholds.

Activity	Distance to NMFS Thresholds			
	190 dB	180 dB	160 dB	120 dB
Anchor Handling	3 m	10 m	100 m	22,104 m
Side Scan Sonar	32 m	100 m	1000 m	--
Ice Management	3 m	10 m	100 m	9,600 m

11.1.2 Shut Down/Power Down Procedures

Mitigation measures typically used in industry programs include powering or shutting down activities if a marine mammal is in or approaching an established zone (based on distances to 190 or 180 dB). For the anchor handling and ice management portions of the program, it is not feasible to implement a power down or shut down procedure. Each anchor weighs between 4,500 and 20,000 pounds; once the anchor has been connected to the winch and is being slowly hauled in, stopping or even slowing the retrieval process could have major safety consequences to the vessel. Accordingly, once the anchor is connected, we will not be able to stop operations if a marine mammal enters the safety zone.

FWS proposes the following mitigation and monitoring scenarios prior to and during actual **anchor retrieval and ice management** to reduce potential exposures of sound on marine mammals.

- When the vessel is positioned on-site, the PSO will 'clear' the area by observing the 160 dB safety zone (100 m) for 30 minutes; if no marine mammals are observed within those 30 minutes, anchor retrieval will commence.
- If a marine mammal(s) is observed within the 160 dB safety zone during the clearing, the PSO will continue to watch until the animal(s) is gone and has not returned for 15 minutes if the sighting was a pinniped, or 30 minutes if it was a cetacean.
- Once the PSO has cleared the area, anchor retrieval operations may commence.
- Should a marine mammal(s) be observed within the 160 dB safety zone during the retrieval operations, the PSO will monitor and carefully record any reactions observed. PSOs will also collect behavioral information on marine mammals beyond the safety zone.

FWS proposes the following mitigation and monitoring scenarios for the **side scan sonar activity**:

- Prior to starting the sonar activity, the PSO will 'clear' the area by observing the 180 dB exclusion zone (100 m) for 30 minutes; if no marine mammals are observed within those 30 minutes, sonar activity will commence.
- If a marine mammal(s) is observed within the 180 dB exclusion zone during the clearing, the PSO will continue to watch until the animal(s) is gone and has not returned for 15 minutes if the sighting was a pinniped, or 30 minutes if it was a cetacean.
- Once the PSO has cleared the area, sonar activity may commence.
- If an animal enters the 180 dB exclusion zone, sonar will be shut down immediately. Sonar activity will not resume until the marine mammal has cleared the exclusion zone. PSOs will also collect behavioral information on marine mammals beyond the exclusion zone.

11.1.3 Speed or Course Alteration

If a marine mammal is detected outside the 160 dB safety zone for anchor handling or ice management (100 m) or the 180 dB exclusion zone for side scan sonar activities (100 m) and, based on its position and the relative motion, is likely to enter those zones, the vessel's speed and/or direct course may, when practical and safe, be changed. The marine mammal activities and movements relative to the vessels will be closely monitored to ensure that the marine mammal does not approach within either zone. If the mammal appears likely to enter the respective zone, further mitigative actions will be taken, i.e., either further course alterations or shut down in the case of the sonar.

11.1.4 PSO Training

PSOs will complete a two or three-day training session on marine mammal monitoring, to be conducted shortly before the anticipated start of the 2016 open-water season. The training session will be led by FWS with the assistance of qualified marine mammologists with extensive crew-leader experience during previous vessel-based monitoring programs. A marine mammal observers' handbook, adapted for the specifics of the planned program, will be reviewed as part of the training. PSO training that is conducted prior to the start of the survey activities will be conducted with both Alaska Native PSOs and biologist PSOs being trained at the same time in the same room. PSOs shall be trained using visual aids (e.g., videos, photos), to help them identify the species that they are likely to encounter in the conditions under which the animals will likely be seen.

11.1.5 Monitoring methodology

Each of the vessels will be staffed with a minimum of two PSOs. PSOs will be on watch during all daylight periods. The observer(s) will watch for marine mammals from the best available vantage point on vessel. Ideally this vantage point is an elevated stable platform from which the PSO has an unobstructed 360° view of the water. The PSOs will scan systematically with the naked eye and 7 x 50 reticle binoculars. When a mammal sighting is made, the following information about the sighting will be carefully and accurately recorded:

- Species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from the PSO, apparent reaction to activities (e.g., none, avoidance, approach, paralleling, etc.), closest point of approach, and behavioral pace;
- Time, location, speed, activity of the vessel, sea state, ice cover, visibility, and sun glare;
- The positions of other vessel(s) in the vicinity of the PSO location; and
- The vessel's position, speed, water depth, sea state, ice cover, visibility, and sun glare will also be recorded at the start and end of each observation watch, every 30 minutes during a watch, and whenever there is a change in any of those variables.

Distances to nearby marine mammals will be estimated with binoculars (Fujinon 7x50 binoculars) containing a reticle to measure the vertical angle of the line of sight to the animal relative to the horizon. Personnel on the bridge will also assist the PSOs in watching for marine mammals. PSOs are instructed to identify animals as unknown when appropriate rather than strive to identify an animal when there is significant uncertainty. FWS also will ask that the PSOs provide any sightings cues they used and any distinguishable features of the animal even if they are not able to identify the animal and record it as unidentified. Emphasis is also placed on recording what was not seen, such as dorsal features. In addition to routine PSO duties, observers will be encouraged to record comments about their observations into the "comment" field in the database. Copies of these records will be available to the observers for reference if they wish to prepare a statement about their observations. If prepared, this statement would be included in the 90-day reports documenting the monitoring work. Throughout the anchor handling program, the PSOs will prepare daily, weekly, and monthly reports as required summarizing the recent results of the monitoring program. The reports will summarize the species and numbers of marine mammals sighted. These reports will be provided to agencies as required.

An electronic database will be used to record and collate data obtained from visual observations. The PSOs will enter the data into the data entry program installed on field laptops. The program automates the data entry process, reduces data entry errors, and maximizes PSO time spent looking at the water. PSOs also have voice recorders available to them that will allow PSOs to maximize time spent focused on the water. Quality control of the data will be facilitated by; (1) the start-of-season training session, (2) subsequent supervision by the onboard field crew leader, and (3) ongoing data checks during the field season. The data will be sent from the vessel to Anchorage on a daily basis, and backed up regularly onto storage devices on the vessel.

12.0 MEASURES TO REDUCE IMPACTS TO SUBSISTENCE USERS

Where the proposed activity would take place in or near a Traditional Arctic Subsistence Hunting area and/or may affect the availability of a species or stock of marine mammal for Arctic subsistence uses, the applicant must submit either a plan of cooperation or information that identifies what measures have been taken and/or will be taken to minimize any adverse effects on the availability of marine mammals for subsistence uses.

NMFS regulations require a plan to include four elements, which are discussed below.

- A statement that the applicant has notified and provided the affected subsistence community with a draft plan of cooperation (POC). The POC can be found in Appendix B.
  - A key component to working in the Arctic is cooperation with the communities to avoid conflict with subsistence activities. Fairweather will operate in a manner that prevents unreasonable conflicts between vessels and the subsistence activities and resources of residents of the North Slope. Fairweather will adhere to USFWS and NMFS regulations, which require an operator to implement a POC to mitigate the potential for conflicts between the proposed activity and traditional subsistence activities (50 CFR § 18.124(c)(4) and 50 CFR § 216.104(a)(12)). FWS will also work with various whaling commissions, Alaska Native organizations, and the Arctic Inupiat Offshore to develop a communication plan.
  - A description of what measures the applicant has taken and/or will take to ensure that proposed activities will not interfere with subsistence hunting
  - Prior to the beginning of the 2016 season, Fairweather will attend the AEWC meeting, participate in Conflict Avoidance Agreement (CAA) discussions, and implement negotiated measures. Fairweather intends to sign the CAA at the AEWC meeting. These measures may include establishing Com Centers. Fairweather will call into operating and established Com Centers.

There are several timing periods important for consideration, including the beluga whale subsistence activities near Kotzebue and in the Chukchi Sea, and bowhead whale subsistence activities in the Chukchi and Beaufort seas (to name a few). Activities near Kotzebue will require additional communication as the anchor locations are nearshore and near where the Village typically hunt beluga whale. The anchor sites in the Chukchi Sea are sufficiently far offshore and are thought by Fairweather to have no impact on subsistence hunting. The goal is to enter the Beaufort Sea as soon as Point Barrow is ice-free and be finished at the Sivulliq location well before the August 25th commencement date of bowhead whaling. Although not anticipated with the proposed schedule, if crew changes are needed, they will occur at either Wainwright or Prudhoe Bay depending on the location of the vessel. FWS will work with the community of Wainwright through our joint venture with Olgoonik Corporation. Through the establishment of village liaisons and onboard PSOs (discussed in more detail below), Fairweather will ensure there are no conflicts with subsistence activities. FWS has worked with seasoned whaling captains for pre-season training and employed PSOs have worked with people in all the communities.

The following mitigation measures and programs to monitor and mitigate potential impacts to subsistence users and resources will be implemented by FWS during its anchor handling operations in the Bering, Chukchi, and Beaufort seas. These mitigation measures reflect FWS's experience conducting vessel operations in the Alaska Arctic OCS since the 1980s. To minimize any cultural or resource impacts from its exploration operations, Fairweather will continue to implement the following additional measures to ensure coordination of its activities with local subsistence users to minimize further the risk of impacting marine mammals and interfering with the subsistence hunt:

12.1 COMMUNICATIONS

FWS has developed a Communication Plan and will implement this plan before initiating the anchor handling program. The Plan will help coordinate activities with local Com Centers and thus subsistence users, minimize the risk of interfering with subsistence hunting activities, and keep current as to the timing and status of the bowhead whale hunt and other subsistence hunts. The Communication Plan includes procedures for coordination with Com Centers to be located in coastal villages along the Chukchi Sea during the proposed anchor handling activities.

FWS may employ local village liaisons from North Slope villages that are potentially impacted by anchor handling activities. The liaisons will provide consultation and guidance regarding the whale migration and subsistence activities. They will use local knowledge (Traditional Knowledge) to gather data on subsistence lifestyle within the community and provide advice on ways to minimize and mitigate potential negative impacts to subsistence resources. Responsibilities include reporting any subsistence concerns or conflicts; coordinating with subsistence users; reporting subsistence-related comments, concerns, and information; coordinating with the Com and Call Center personnel; and advising how to avoid subsistence conflicts.

Throughout 2016, FWS anticipates continued engagement with the marine mammal commissions and committees active in the subsistence harvests and marine mammal research. We are scheduled to present our operations at the mini-convention at the AEWC the week of Feb 1-5 and will participate in all CAA discussions with the intent of signing the CAA.

12.2 VESSEL TRAVEL

- The vessels will enter the Bering Strait and continue to the Chukchi Sea on or after 1 July, minimizing effects on marine mammals that frequent open leads and minimizing effects on spring and early summer bowhead whale hunting.
- The transit route for the vessels will avoid known protected ecosystems such as the Ledyard Bay Critical Habitat Unit (LBCHU), and will include coordination through Com Centers.
- PSOs will be aboard vessels.
- When within 805 m of whales, vessels will reduce speed, avoid separating members from a group and avoid multiple changes of direction.
- Vessel speed will be reduced during inclement weather conditions in order to avoid collisions with marine mammals.
- Personnel will communicate and coordinate with the Com Centers regarding all vessel transit.

13.0 MONITORING AND REPORTING

The suggested means of accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species, the level of taking or impacts on populations of marine mammals that are expected to be present while conducting activities and suggested means of minimizing burdens by coordinating such reporting requirements with other schemes already applicable to persons conducting such activity. Monitoring plans should include a description of the survey techniques that would be used to determine the movement and activity of marine mammals near the activity site(s) including migration and other habitat uses, such as feeding. Guidelines for developing a site-specific monitoring plan may be obtained by writing to the Director, Office of Protected Resources.

13.1 REQUIRED MONITORING AND REPORTING

The results of vessel-based monitoring, including estimates of exposure to key sound levels, will be presented in weekly, monthly, and 90-day reports. Reporting will address the requirements established by NMFS in the IHA, and USFWS in the LOA (if so stipulated). The technical report(s) will include the list below. Additional reporting guidelines can be found in FWS's 4MP.

- Summaries of monitoring effort: total hours, total distances, and distribution of marine mammals throughout the study period compared to sea state, and other factors affecting visibility and detectability of marine mammals;
- Analyses of the effects of various factors influencing detectability of marine mammals: sea state, number of observers, and fog/glare;
- Species composition, occurrence, and distribution of marine mammal sightings including date, water depth, numbers, age/size/gender categories (when discernable), group sizes, and ice cover;
- Analyses of the effects of anchor handling program:
    - Sighting rates of marine mammals during periods with and without anchor handling activities (and other variables that could affect detectability),
    - Initial sighting distances versus vessel location,
    - Closest point of approach versus vessel location,
    - Observed behaviors and types of movements versus vessel location,
    - Numbers of sightings/individuals seen versus vessel location,
    - Distribution around the drillship and support vessels versus vessel location, and
    - Estimates of "take by harassment".

13.2 MARINE MAMMAL BEHAVIORAL RESPONSE TO VESSEL DISTURBANCE STUDY

As part of the Chukchi Sea Environmental Studies Program (CSESP), marine mammal biologists collected behavioral response data on walruses and seals to the vessel (either R/V *Westward Wind* or *Norseman II*). The objectives of the observer on the CSESP program were to collect information on marine mammal distribution and density estimates using standard line-transect theory; in other words, the program was not a mitigation program for any particular seismic activity. When in the presence of walruses in the Hanna Shoal Walrus Use Area (HSWUA), we were able to collect behavioral response data to vessel disturbance to walruses (McFarland et al. 2015). Because the vessels in this program will be transiting a large portion of the time, we propose to utilize this opportunity to collect information on responses of marine mammals, particularly walruses and seals, to vessel disturbance. We will utilize the same protocol approved by USFWS in 2014 (Christman et al. 2015).

As part of the standard FWS observation protocol, observers will record the initial and subsequent behaviors of marine mammals, a methodology we refer to as ‘focal following’. Marine mammals will be monitored and observed until they disappear from the PSO’s view (PSOs may have to follow the walruses by moving to new locations in order to keep the walruses in constant view. Observers will also record any perceived reactions that marine mammals may have in response to the vessel. When following the animal use either a notebook or voice recorder to note any changes in behavior and the time when these changes occur. Time of first observation, time of changes in behavior, and time last seen will be recorded. Behaviors and changes in behaviors of marine mammals will be recorded as long as they are in view of the boat. After the animal is out of sight, PSOs will summarize the observation in the notes field of the electronic data collection platform. It may be difficult to find the animal being followed after it dives and if this happens, PSO will stop focal follow observation.

For groups of marine that are too large to monitor each animal one or more focal animals, e.g., cow/calf pair, subadult female, adult male, etc., will be chosen to monitor until no longer observable. For a sighting with more than one animal, the most common behavior of the group will be recorded. Focal animals will be chosen without bias in relation to age and sex, but as observations accumulate and specific age/sex categories are underrepresented, focal animals may be chosen from those underrepresented categories if possible.

A separate section in the 90-day report will be provided with a summary of results of vessel disturbance, with the ultimate goal of a peer-reviewed publication.

14.0 RESEARCH COORDINATION

Suggested means of learning of, encouraging, and coordinating research opportunities, plans, and activities relating to reducing such incidental taking and evaluating its effects.

Various agencies and programs may undertake marine mammal studies in the Arctic during the course of the project season. It is unclear whether these studies will be relevant to the planned anchor handling program. Fairweather is prepared to share information obtained during implementation of our marine mammal monitoring and mitigation program with a variety of groups who may find the data useful in their research.

Through our joint venture with Olgoonik Corporation, Olgoonik Fairweather has hosted a daily call with all vessels and any interested stakeholders during the open water season for sharing of information at 16:00. We will continue this and will include other researchers known to operate in the area during the 2016 season.

A suggested list of recipients includes:

- The North Slope Borough (NSB) Department of Wildlife Management (T. Hepa)
- NSB Planning Commission
- The USFWS Office of Marine Mammal Management (C. Perham, C. Putnam, and J. MacCracken)
- The BOEM's ASAMM (J. Denton)
- NOAA, NMML (Robyn Angliss)
- The Kuukpik Subsistence Oversight Panel (KSOP)
- AEWC (G.Noongwook -Savoonga)
- ABWC (W. Goodwin -Kotzebue)
- Ice Seal Committee (J. Goodwin – Kotzebue)
- Co-Management Groups
- Inupiat Community of the Arctic Slope (D. Lampe -Barrow)
- North Slope Science Initiative (NSSI)
- Alaska Department of Natural Resources
- ADFG

15.0 REFERENCES

ADFG (Alaska Department of Fish and Game). 1994. Orca: Wildlife Notebook Series. Alaska Department of Fish & Game. Available at: www.adfg.state.ak.us/pubs/notebook/marine/orca.php

ADFG. 2010. Satellite Tracking of Western Arctic Bowhead Whales. Preliminary reports and summaries available at: http://www.wildlife.alaska.gov/index.cfm?adfg=marinemammals.bowhead

ADFG. 2012. Satellite Tracking of Western Arctic Bowhead Whales. Weekly Maps available at: http://www.wildlife.alaska.gov/index.cfm?adfg=marinemammals.bowhead

Aerts, L.A.M., A. Kirk, C. Schudel, K. Lomac-Macnair, A. Mcfarland, P. Seiser, and B. Watts. 2011. Marine Mammal Distribution and Abundance in the Northeastern Chukchi Sea, July-October 2008-2010. Report prepared by OASIS Environmental, Inc. for ConocoPhillips Alaska, Inc., Shell Exploration and Production Company and Statoil USA E&P, Inc. 52 pp. plus Appendices.

Aerts, L.A.M., A. Kirk, C. Schudel, B. Watts, P. Seiser, A. Mcfarland, and K. Lomac-Macnair. 2012. Marine Mammal Distribution and Abundance in the Northeastern Chukchi Sea, July-October 2008-2011. Report prepared by LAMA Ecological for ConocoPhillips Alaska, Inc., Shell Exploration and Production Company and Statoil USA E&P, Inc. 69 pp.

Aerts, L.A.M., W. Hetrick, S. Sitkiewicz, C. Schudel, D. Snyder, and R. Gumtow. 2013. Marine mammal distribution and abundance in the northeastern Chukchi Sea during summer and early fall, 2008-2012. Final Report prepared by LAMA Ecological for ConocoPhillips Company., Shell Exploration and Production Company and Statoil USA E&P, Inc.

Allen, B.M., and R.P. Angliss. 2014. Alaska Marine Mammal Stock Assessments, 2013. U.S. Dep. Commer., NOAA Technical Memorandum NMFS-AFSC-277, 294 p.

Allen, B. M., and R. P. Angliss. 2015. Alaska marine mammal stock assessments, 2014. U.S. Dep. Commer., NOAA Tech. Memo. NMFS AFSC-301, 304 p. doi:10.7289/V5NS0RTS.

Austin, M., A. McCrodan, C. O'Neill, Z. Li, and A. MacGillivray. 2013. Underwater Sound Measurements. (Chapter 3) In: Bisson, L.N., H.J. Reider, H.M. Patterson, M. Austin, J.R. Brandon, T. Thomas, and M.L. Bourdon. 2013. Marine mammal monitoring and mitigation during exploratory drilling by Shell in the Alaskan Chukchi and Beaufort seas, July–November 2012: Draft 90-Day Report. Editors: D.W. Funk, C.M. Reiser, and W.R. Koski. LGL Rep. P1272D–1. Rep. from LGL Alaska Research Associates Inc., Anchorage, AK, USA, and JASCO Applied Sciences, Victoria, BC, Canada, for Shell Offshore Inc., Houston, TX, USA, Nat. Mar. Fish. Serv., Silver Spring, MD, USA, and U.S. Fish and Wild. Serv., Anchorage, AK, USA. 266 pp, plus appendices.

Balcomb, K.C., III and D.E. Claridge. 2001. A mass stranding of cetaceans caused by naval sonar in the Bahamas. Bahamas J. Sci. 8(2):2-12.

Bengtson, J.L., L.M. Hiruki-Raring, M.A. Simpkins, and P.L. Boveng. 2005. Ringed and bearded seal densities in the eastern Chukchi Sea, 1999-2000. Polar Biol. 28:833-845-230.

Bisson, L.N., H.J. Reider, H.M. Patterson, M. Austin, J.R. Brandon, T. Thomas, and M.L. Bourdon. 2013. Marine mammal monitoring and mitigation during exploratory drilling by Shell in the Alaskan Chukchi and Beaufort seas, July–November 2012: Draft 90-Day Report. Editors: D.W. Funk, C.M.

Reiser, and W.R. Koski. LGL Rep. P1272D–1. Rep. from LGL Alaska Research Associates Inc., Anchorage, AK, USA, and JASCO Applied Sciences, Victoria, BC, Canada, for Shell Offshore Inc, Houston, TX, USA, Nat. Mar. Fish. Serv., Silver Spring, MD, USA, and U.S. Fish and Wild. Serv., Anchorage, AK, USA. 266 pp, plus appendices.

Blackwell, S.B. and C.R. Greene, Jr. 2002. Acoustic measurements in Cook Inlet, Alaska, during August 2001. Rep. prepared by Greeneridge Sciences, Inc., Santa Barbara, CA, for the Nat. Mar. Fish. Serv. Anchorage, AK.

Blackwell, S.B., R.G. Norman, C.R. Greene Jr., M.W. McLennan, T.L. McDonald and W.J. Richardson. 2004. Acoustic monitoring of bowhead whale migration, autumn 2003. p. 71 to 744 In: Richardson, W.J. and M.T. Williams (eds.) 2004. Monitoring of industrial sounds, seals, and bowhead whales near BP's Northstar oil development, Alaskan Beaufort Sea, 1999-2003. [Dec. 2004 ed.] LGL Rep. TA4002. Rep. from LGL Ltd. (King City, Ont.), Greeneridge Sciences Inc. (Santa Barbara, CA) and WEST Inc. (Cheyenne, WY) for BP Explor. (Alaska) Inc., Anchorage, AK. 297 p. + Appendices A - N on CD-ROM.

Blackwell, S.B. and C.R. Greene, Jr. 2005. Underwater and in–air sounds from a small hovercraft. J Acoust. Soc. Am. 118(6):3646–3652.

Blackwell, S.B. and C.R. Greene, Jr. 2006. Sounds from an oil production island in the Beaufort Sea in summer: characteristics and contribution of vessels. J Acoust. Soc. Am.119(1):182–196.

Blackwell, S.B., C.R. Greene, T.L. McDonald, M.W. McLennan, C.S. Nations, R.G. Norman, and A. Thode. 2009a. Beaufort Sea bowhead whale migration route study. (Chapter 8) In: Ireland, D.S., D.W. Funk. R. Rodrigues, and W.R. Koski (eds.). 2009. Joint Monitoring Program in the Chukchi and Beaufort seas, open water seasons, 2006–2007. LGL Alaska Report P971–2, Report from LGL Alaska Research Associates, Inc., Anchorage, AK, LGL Ltd., environmental research associates, King City, Ont., JASCO Research, Ltd., Victoria, BC, and Greeneridge Sciences, Inc., Santa Barbara, CA, for Shell Offshore, Inc., Anchorage, AK, ConocoPhillips Alaska, Inc., Anchorage, AK, and the National Marine Fisheries Service, Silver Springs, MD, and the U.S. Fish and Wildlife Service, Anchorage, AK. 485 p. plus Appendices.

Bluhm, B.A., K.O. Coyle, B. Konar and R. Highsmith. 2007. High gray whale relative abundances associated with an oceanographic front in the south-central Chukchi Sea. Deep-sea Research II 54:2919-2933.

Bluhm B.A., R. Gradinger. 2008. Regional variability in food availability for Arctic marine mammals. Ecological Applications. 18: S77-S96.

Boveng, P. L., J. L. Bengtson, T. W. Buckley, M. F. Cameron, S. P. Dahle, B. P. Kelly, B. A. Megrey, J. E. Overland, and N. J. Williamson. 2009. Status review of the spotted seal (*Phoca largha*). U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-200, 153 p.

Braham, H. W., M. A. Fraker, and B. D. Krogman. 1980. Spring migration of the western Arctic population of bowhead whales. Mar. Fish. Rev. 42(9-10):36-46.

Braham, H. W., and M. E. Dahlheim. 1982. Killer whales in Alaska documented in the Platforms of Opportunity Program. Rep. Int. Whal. Comm. 32:643-646.

Braham, H. W., and D. W. Rice. 1984. The right whale, *Balaena glacialis*. Mar. Fish. Rev. 46(4):38-44.

Braham, H.W., B.D. Krogman and G.M. Carroll. 1984. Bowhead and white whale migration, distribution, and abundance in the Bering, Chukchi, and Beaufort seas, 1975-78. NOAA Tech. Rep. NMFS SSRF-778. USDOC/NOAA/NMFS. NTIS PB84-157908. 39 p.

Brandsma, M., L. Davis, R. Ayers, Jr., and T. Sauer, Jr. 1980. A computer model to predict the short-term fate of drilling discharges in the marine environment. pp 588 - 608 in Proceedings of symposium, research on environmental fate and effects of drilling fluids and cuttings, January 21-24, 1980, Lake Buena Vista, Florida American Petroleum Institute, Washington, DC.

Brewer, K.D., M.L. Gallagher, P.R. Regos, P.E. Isert, and J.D. Hall. 1993. Kuvlum #1 exploration prospect final report – site specific monitoring program. Report from Coastal & Offshore Pacific Corporation, Walnut Creek, CA, for ARCO Alaska. Inc.

Brower, H., Jr. 1996. Observations on locations at which bowhead whales have been taken during the fall subsistence hunt (1988 through 1995) by Eskimo hunters based in Barrow, Alaska. North Slope Borough Dep. Wildl. Manage., Barrow, AK. 8 p. Revised 19 Nov. 1996.

Brueggeman, J. 2009. Marine mammal surveys at the Klondike and Burger survey areas in the Chukchi Sea during the 2008 open water season. Report prepared for ConocoPhillips Alaska, Inc. and Shell Exploration and Production Company. 50 p.

Brueggeman, J. 2010. Marine mammal surveys at the Klondike and Burger survey areas in the Chukchi Sea during the 2009 open water season. Report prepared for ConocoPhillips, Inc., Shell Exploration and Production Company, and Statoil USA E&P Inc. 59 p.

Burns, J.J. 1970. Remarks on the distribution and natural history of pagophilic pinnipeds in the Bering and Chukchi Seas. J. Mammal. 51(3):445-454.

Burns, J.J. 1981. Ribbon seal—*Phoca fasciata*. Page 89-109 In S. H. Ridgway and R. J. Harrison (eds.), Handbook of marine mammals. Vol. 2. Seals. Academic Press, New York.

Burns, J.J. 1981b. Bearded seal *Erignathus barbatus* Erxleben, 1777. p. 145-170 In: S.H. Ridgway and R.J. Harrison (eds.), Handbook of Marine Mammals, Vol. 2: Seals. Academic Press, New York.

Burns, J., J. Montague, and C. Cowles (eds.). 1993. The bowhead whale. Special Publication of The Society for Marine Mammalogy No.2. The Society for Marine Mammalogy. Lawrence, KS.

Cameron, M., P. Boven, J. Goodwin, and A. Whiting. 2009. Seasonal movements, habitat selection, foraging and haul-out behavior of adult bearded seals. Poster Presentation: Bio. of Mar. Mam. 18th Biennial Conf., Soc.for Mar. Mamm., Quebec City, Canada, Oct 2009.

Cameron, M. F., J. L. Bengtson, P. L. Boveng, J. K. Jansen, B. P. Kelly, S. P. Dahle, E. A. Logerwell, J. E. Overland, C. L. Sabine, G. T. Waring, and J. M. Wilder. 2010. Status review of the bearded seal (Erignathus barbatus). U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-211, 246 p.

Centaur Associates, Inc. 1984. Sea Floor Conflicts Between Oil and Gas Pipelines and Commercial Trawl Fisheries on the California Outer Continental Shelf. OCS Study MMS 84-0058, U.S. Department of the Interior, Washington D.C. 270 pp.

Christie, K., C. Lyons, and W.R. Koski. 2010. Beaufort Sea aerial monitoring program. (Chapter 7) In: Funk, D.W, D.S. Ireland, R. Rodrigues, and W.R. Koski (eds.). 2010. Joint Monitoring Program in the Chukchi and Beaufort seas, open water seasons, 2006–2008. LGL Alaska Report P1050-3, Report from LGL Alaska Research Associates, Inc., LGL Ltd., Greeneridge Sciences, Inc., and JASCO Research, Ltd., for Shell Offshore, Inc. and Other Industry Contributors, and National Marine Fisheries Service, U.S. Fish and Wildlife Service. 499 p. plus Appendices.

Christman, C., L. Aerts, W. Hetrick, and D. Snyder. 2015. Chukchi and Beaufort Sea Environmental Studies August-October 2014 Polar Bear and Walrus Observations. 90-day Report submitted to USFWS by Olgoonik Fairweather LLC.

Clarke, J., S. Moore, and D. Ljungblad. 1989. Observations on the gray whale (*Eschrichtius robustus*) utilization and patterns in the northeast Chukchi Sea, July-October 1982-1987. Canadian Journal of Zoology 67:2646-2653.

Clarke, J. T., and M. C. Ferguson. 2010a. Aerial surveys for bowhead whales in the Alaskan Beaufort Sea: BWASP update 2000-2009 with comparisons to historical data. Unpubl. doc. Submitted to Int. Whal. Comm. (SC/62/BRG14).

Clarke, J. T., and M. C. Ferguson. 2010b. Aerial surveys of large whales in the northeastern Chukchi Sea, 20082009, with review of 1982-1991 data. Unpubl. doc. submitted to Int. Whal. Comm. (SC/62/BRG13).

Clarke, J.T. and M.C. Ferguson. In prep. Distribution and relative density of large whales in the northeastern Chukchi Sea: similarities and differences between a 17-year data gap, 1982-1991 and 2008-2010.

Clarke, J.T., Ferguson, M.C., Christman, C.L., Grassia, S.L., Brower, A.A. and Morse, L.J. 2011. Chukchi Offshore Monitoring in Drilling Area (COMIDA) Distribution and Relative Abundance of Marine Mammals: Aerial Surveys. Final Report, OCS Study BOEMRE 2011-06. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC3, Seattle, WA 98115-6349.

Clarke, J.T., C.L. Christman, A.A. Brower, and M.C. Ferguson. 2012. Distribution and relative abundance of marine mammals in the Alaskan Chukchi and Beaufort seas, 2011. Annual Report, OCS Study BOEM 2012-09. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC3, Seattle, WA 98115-6349.

Clarke, J.T., C.L. Christman, A.A. Brower, and M.C. Ferguson. 2013. Distribution and relative abundance of marine mammals in the northeastern Chukchi and western Beaufort seas, 2012. Annual Report, OCS Study BOEM 2013-00117. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC3, Seattle, WA 98115-6349.

Clarke, J.T., C.L. Christman, A.A. Brower, and M.C. Ferguson. 2014. Distribution and relative abundance of marine mammals in the northeastern Chukchi and western Beaufort Seas, 2013: Annual Report. Bureau of Ocean Energy Management OCS Study BOEM 2014-018, 330 pages.

Conn, P. B., J. M. Ver Hoef, B. T. McClintock, E. E. Moreland, J. M. London, M. F. Cameron, S. P. Dahle, and P. L. Boveng. 2014. Estimating multispecies abundance using automated detection systems: ice-associated seals in the Bering Sea. Methods in Ecology and Evolution 5:1280-1293. doi: 10.1111/2041-210X.12127.

Coyle, K.O., B. Bluhm, B. Konar, A. Blanchard and R.C. Highsmith. 2007. Amphipod prey of gray whales in the northern Bering Sea: Comparison of biomass and distribution between the 1980s and 2002-3. Deep-sea Research II 54:2906-2918.

Crawford J.A., K.J. Frost, and L.T. Quakenbush. 2012. Different habitat use strategies by sub adult and adult ringed seals (*Phoca hispida*) in the Bering and Chukchi seas. Polar Biology. 35 (2): 241-255.

Dahlheim, M.E. and J.E. Heyning. 1999. Killer whale *Orcinus orca* (Linnaeus, 1758). p. 281-322 In: S.H. Ridgway and R. Harrison (eds.), Handbook of Marine Mammals, Vol. 6: The Second Book of Dolphins and the Porpoises. Academic Press, San Diego, CA. 486 p.

Davis, R. 1987. Integration and summary report. pp. 1-51 in: Responses of bowhead whales to an offshore drilling operation in the Alaskan Beaufort Sea, autumn 1986. Prepared by LGL Limited, King City, Ont. and Greenridge Sciences, Inc., Santa Barbara, CA for Shell Western E&P, Inc., Anchorage, AK 371 pp.

Davies, J. R. 1997. The impact of an offshore drilling platform on the fall migration path of bowhead whales: a GIS-based assessment. Unpubl. MS Thesis, Western Washington Univ., Bellingham, WA. 51 pp.

Delarue J., B. Martin, X. Mouy, J. MacDonnell, J. Vallarta, N.E. Chorney, and D. Hannay (Ed.). 2011. Northeastern Chukchi Sea Joint Acoustic Monitoring Program 2009–2010. December 2011.

Delarue, J., J. MacDonnell, B. Martin, X. Mouy, D. Hannay, N.E. Chorney, and J. Vallarta. 2012. Northeastern Chukchi Sea Joint Acoustic Monitoring Program 2010–2011. JASCO Applied Sciences Document 00301, Version 1.0. Technical report for ConocoPhillips Company, Shell Exploration & Production Company, and Statoil USA E&P, Inc. by JASCO Applied Sciences.

Department of the Navy, Chief of Naval Operations. 2001. Final overseas environmental impact statement and environmental impact statement for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar. Volume 1. January 2001. Unpublished report available from Marine Acoustics Inc., Arlington, VA.

Dunton, K., S. Schonberg, and N. McTigue. 2008. Impact Assessment for Exploratory Drilling in Camden Bay (Sivulliq), Alaska Summer 2008. Re-submitted to: Shell Alaska, Anchorage, Alaska, 6 April 2009. The University of Texas Marine Science Institute, 750 Channel View Drive, Port Aransas, TX 78373.

Duval, W. S. 1993. Proceedings of a workshop on Beaufort Sea beluga: February 3-6, 1992. Vancouver, B.C. Env. Studies Res. Found. Rep. No 123. Calgary. 33 pp. + appendices.

Fedoseev, G. A. 2000. Population biology of ice-associated forms of seals and their role in the northern Pacific ecosystems. Center for Russian Environmental Policy, Russian Marine Mammal Council, Moscow, Russia. 271 p. (Translated from Russian by I. E. Sidorova, 271 p.).

Finley, K.J. 1982. The estuarine habitat of the beluga or white whale, *Delphinapterus leucas*. Cetus 4:4-5.

Finley, K.J., G.W. Miller, R.A. Davis and W.R. Koski. 1983. A distinctive large breeding population of ringed seals (*Phoca hispida*) inhabiting the Baffin Bay pack ice. Arctic 36(2):162-173.

Finley, K.J., Miller, G.W., Davis, R.A., and Greene, C.R., Jr. 1990. Reactions of belugas, D*elphinapterus leucas*, and narwhals, *Monodon monoceros*, to ice-breaking ships in the Canadian high arctic. Canadian Bulletin of Fisheries and Aquatic Sciences, 224, 97-117.

Finneran, J.J., C.E. Schlundt, R. Dear, D.A. Carder, and S.H. Ridgway. 2002. Temporary shift in masked hearing thresholds in odontocetes after exposure to single underwater impulses from a seismic watergun. J. Acoust. Soc. Am. 111:2929-2940.

Finneran, J.J., D.A. Carder, C.E. Schlundt, and S.H. Ridgway. 2005. Temporary threshold shift in bottlenose dolphins (*Tursiops truncatus*) exposed to mid-frequency tones. J. Acoust. Soc. Am. 118(4):2696-2705.

Foote, A.D., R.W. Osborne, and A.R. Hoelzel. 2004. Whalecall response to masking boat noise. Nature 428:910.

Friday, N. A., A. N. Zerbini, J. M. Waite, and S. E. Moore. 2012. Cetacean distribution and abundance in relation to oceanographic domains on the eastern Bering Sea shelf: 1999-2004. Deep-Sea Res. II (65-70):260-272.

Friday, N. A., A. N. Zerbini, J. M. Waite, S. E. Moore, and P. J. Clapham. 2013. Cetacean distribution and abundance in relation to oceanographic domains on the eastern Bering Sea shelf in June and July of 2002, 2008, and 2010. Deep-Sea Res. II 94: 244-256.

Frost, K.J. 1985. The ringed seal. Unpubl. Rep., Alaska Dep. Fish. and Game, Fairbanks, Alaska. 14 p.

Frost, K. J., L. F. Lowry, and G. Carroll. 1993. Beluga whale and spotted seal use of a coastal lagoon system in the northeastern Chukchi Sea. Arctic 46:8-16.

Frost, K. J., L. F. Lowry, G. Pendleton, and H. R. Nute. 2004. Factors affecting the observed densities of ringed seals, *Phoca hispida*, in the Alaskan Beaufort Sea, 1996-99. Arctic 57:115-128.

Funk., D.W., D.S. Ireland, R. Rodrigues, and W.R. Koski (eds.). 2010. Joint Monitoring Program in the Chukchi and Beaufort seas, open-water seasons, 2006–2008. LGL Alaska Report P1050-3, Report from LGL Alaska Research Associates, Inc., LGL Ltd., Greeneridge Sciences, Inc., and JASCO Research , Ltd., for Shell Offshore, Inc. and Other Industry Contributors, and National Marine Fisheries Service, U.S. Fish and Wildlife Service. 499 p. plus Appendices.

Gambell, R. 1985. Fin whale *Balaenoptera physalus* (Linnaeus, 1758). p. 171-192 In: S.H. Ridgway and R. Harrison (eds.), Handbook of Marine Mammals, Vol. 3: The Sirenians and Baleen Whales. Academic Press, London, U.K. 362 p.

Garner, W. and D. Hannay. 2009. Sound measurements of Pioneer vessels. Chapter 2 In: Link, M.R. and R. Rodrigues (eds.). Monitoring of in-water sounds and bowhead whales near the Oooguruk and Spy Island drill sites in eastern Harrison Bay, Alaskan Beaufort Sea, 2008. Rep. from LGL Alaska Research Associates, Inc., Anchorage, AK, Greeneridge Sciences, Inc., Santa Barbara, CA, and JASCO Applied Sciences, Victoria, BC, for Pioneer Natural Resources, Inc, Anchorage, AK, and Eni US Operating Co. Inc., Anchorage, AK.

Gaskin, D. E. 1984. The harbor porpoise *Phocoena phocoena* (L.): Regional populations, status, and information on direct and indirect catches. Rep. Int. Whal. Comm. 34:569-586.

George, J.C. and R. Tarpley. 1986. Observations in the 1984 and 1985 subsistence harvest of bowhead whales, *Balaena mysticetus*, with a note on the fall 1983 harvest. Rep. Int. Whal. Comm. 36, SC/37/PS16. Cambridge, UK.

George, J.C., G.M. Carroll, R. Tarpley, T.F. Albert, and R.L. Yackley. 1987. Report of field activities pertaining to the spring 1986 census of bowhead whales, *Balaena mysticetus*, off Point Barrow, Alaska with observations on the subsistence hunt. Rep. Int. Whal. Comm. 37, SC/38/PS5. Cambridge, UK.

George, J.C., L.M. Philo, G. Carroll, and T.F. Albert. 1988. 1987 subsistence harvest of bowhead whales *Balaena mysticetus* by Alaska Eskimos. Rep. Int. Whal. Comm. 42, SC/43/PS18. Cambridge, UK.George, J.C., G.M. Carroll, L.M. Philo, and T.F. Albert. 1990. Report of field activities of the spring 1988 census of bowhead whales, (*Balaena mysticetus)* off Point Barrow, Alaska with observations on the subsistence hunt. Rep. Int. Whal. Comm. 40, SC/41/PS7. Cambridge, UK.

George, J.C., L.M. Philo, R. Suydam, R. Tarpley, and T.F. Albert. 1992. Summary of the 1989 and 1990 subsistence harvest of bowhead whales *Balaena mysticetus* by Alaska Eskimos. Rep. Int. Whal. Comm. 42, SC/43/PS18. Cambridge, UK.

George, J.C., R.S. Suydam, L.M. Philo, T.F. Albert, J.E. Zeh, and G. Carroll. 1995. Report of the spring 1993 census of bowhead whales *Balaena mysticetus* off Point Barrow, Alaska with observations on the subsistence hunt of bowhead whales by Alaska Eskimos. Rep. Int. Whal. Comm. 45, SC/46/AS17. Cambridge, UK.

George, J.C., T. O'Hara, H. Brower, Jr., and R. Suydam. 1998. Results of the 1997 subsistence harvest of bowhead whales by Alaskan Eskimos with observations on the influence of environmental conditions on the success of hunting bowhead whales off Barrow, Alaska. Rep. Int. Whal. Comm., Paper SC/50/AS9. Cambridge, UK.

George, J.C., L.M. Philo, K. Hazard, D. Withrow, G.M. Carroll, and R. Suydam. 1994. Frequency of killer whale (*Orcincus orca*) attacks and ship collisions based on scarring on bowhead whales (*Balaena mysticetus*) of the Bering-Chukchi-Beaufort Sea stock. Arctic 47(3):247-255.

George, J.C., and R. Suydam. 1998. Observations of killer whales (*Orcincus orca*) predation in the northeastern Chukchi and western Beaufort seas. Mar. Mamm. Sci. 14:330-332.

George, J.C., T. O'Hara, and R. Suydam. 1999. Observations on the 1998 subsistence harvest of bowhead whales by Alaskan Eskimos with a note on the late 1998 and early 1999 environmental conditions near Barrow, Alaska. Rep. Int. Whal. Comm., Paper SC/51/AS22. Cambridge, UK.

George, J.C., R. Suydam, T. O'Hara, and G. Sheffield. 2000. Subsistence harvest of bowhead whale by Alaskan Eskimos during 1999. Rep. Int. Whal. Comm., Paper SC/51/AS24. Cambridge, UK.

George, J.C., J. Zeh, R. Suydam, and C. Clark. 2004. Abundance and population trend (1978-2001) of Western Arctic bowhead whales surveyed near Barrow, Alaska. Mar. Mamm. Sci. 20(4):755-773.

Givens, G.H., S.L. Edmondson, J.C. George, R. Suydam, R.A. Charif, A. Rahaman, D. Hawthorne, B. Tudor, R.A. DeLong, and C.W. Clark. 2013. Estimate of 2011 abundance of the Bering-Chukchi-Beaufort seas bowhead whale population. Rep. Int. Whal. Comm., Paper SC/65a/BRG01. Cambridge, UK.

Greene, C.R., Jr., and S.E. Moore. 1995. Man made noise, Chapter 6 In W.J. Richardson, C.R. Greene, Jr., C.I. Malme, and D.H. Thomson (eds.). Marine Mammals and Noise. Academic Press, San Diego, CA.

Greene, C.R., Jr. 1997. Physical acoustics measurements. (Chap. 3, 63 p.) In: W.J. Richardson (ed.), 1997. Northstar Marine Mammal Marine Monitoring Program, 1996. Marine mammal and acoustical monitoring of a seismic program in the Alaskan Beaufort Sea. Rep. TA2121-2. Rep. from LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, for BP Explor. (Alaska) Inc., Anchorage, AK, and U.S. Nat. Mar. Fish. Serv., Anchorage, AK, and Silver Spring, MD. 245 p.

Greene, C.R., Jr., N.S. Altman and W.J. Richardson. 1999. Bowhead whale calls. p. 6-1 to 6-23 In: W.J. Richardson (ed.), Marine mammal and acoustical monitoring of Western Geophysical's open-water seismic program in the Alaskan Beaufort Sea, 1998. LGL Rep. TA2230-3. Rep. from LGL Ltd., King City, ON, and Greeneridge Sciences Inc., Santa Barbara, CA, for Western Geophysical, Houston, TX, and U.S. Nat. Mar. Fish. Serv., Anchorage, AK, and Silver Spring, MD. 390 p.

Greene, C.R., Jr., R.G. Norman, S.B. Blackwell, and A. Thode. 2007. Acoustics research for studying bowhead migration, 2006. Chapter 10 In D.S. Ireland, D.W. Funk, R. Rodrigues, and W.R. Koski (eds.). Joint monitoring program in the Chukchi and Beaufort seas, July-November 2006. LGL Rep. P891-2. Prepared by LGL Alaska Research Associates, Inc., Anchorage, AK, and LGL Ltd., environmental research associates, King City, Ont., for Shell Offshore Inc., ConocoPhillips Alaska, Inc., GX T.

Hall, J.D., M.L. Gallagher, K.D. Brewer, P.R. Regos and P.E. Isert. 1994. 1993 Kuvlum exploration area site specific monitoring program final report. Report from Coastal & Offshore Pacific Corporation, Walnut Creek, CA, for ARCO Alaska, Inc.

Hammill, M.O., C. Lydersen, M. Ryg, and T.G. Smith. 1991. Lactation in the ringed seal (*Phoca hispida*). Can. J. Fish. Aquatic Sci. 48(12):2471-2476.

Härkönen, T., O. Stenman, M. Jüssi, I. Jüssi, R. Sagitov, and M. Verevkin. 1998. Population size and distribution of the Baltic ringed seal (*Phoca hispida botnica*). Pages 167-180 in M. P. Heide-Jørgensen and C. Lydersen, editors. Ringed Seals in the North Atlantic. NAMMCO Scientific Publications, Volume 1, Tromsø, Norway.

Harris, R.E., G.W. Miller and W.J. Richardson. 2001. Seal responses to airgun sounds during summer seismic surveys in the Alaskan Beaufort Sea. Mar. Mamm. Sci. 17(4):795-812.

Hartin, K.G., C.M. Reiser, D.S. Ireland, R. Rodrigues, D.M.S. Dickson, J. Beland, and M. Bourdon. 2013. Chukchi Sea vessel-based monitoring program. (Chapter 3) In: Funk, D.W., C.M. Reiser, D.S. Ireland, R. Rodrigues, and W.R. Koski (eds.). 2013. Joint Monitoring Program in the Chukchi and Beaufort seas, 2006–2010. LGL Alaska Report P1213-2, Report from LGL Alaska Research Associates, Inc., LGL Ltd., Greeneridge Sciences, Inc., and JASCO Research, Ltd., for Shell Offshore, Inc. and Other Industry Contributors, and National Marine Fisheries Service, U.S. Fish and Wildlife Service. 592 p. plus Appendices.

Hartline, K., P. Lenz, and C. Herren. 1996. Physiological and behavioural studies of escape responses in Calanoid copepods. Marine and Freshwater Behavior and Physiology 27:199-212.

Harwood, L.A., S. Innes, P. Norton, and M.C.S. Kingsley. 1996. Distribution and abundance of beluga whales in the Mackenzie estuary, southeast Beaufort Sea, and west Amundsen Gulf during late July 1992. Can. J. Fish. Aquatic Sci. 53:2262-2273.

Harwood, J. and B. Wilson. 2001. The implications of developments on the Atlantic Frontier for marine mammals. Cont. Shelf Res. 21(8-10):1073-1093.

Harwood, L.A., F. McLaughlin, R.M. Allen, J. Illasiak Jr. and J. Alikamik. 2005. First-ever marine mammal and bird observations in the deep Canada Basin and Beaufort/Chukchi seas: expeditions during 2002. Polar Biol. 28(3):250-253.

Harwood, L. A. and M. C. S. Kingsley. 2013. Trends in the offshore distribution and relative abundance of Beaufort Sea belugas, 1982-85 vs 2007-09. Arctic 66(3):247-256.

Hashagen, K.A., G.A. Green, and B. Adams. 2009. Observations of humpback whales, *Megaptera novaeangliae*, in the Beaufort Sea, Alaska. Northwestern Naturalist. 90 (2):160-162.

Hastings, M.C. and Popper, A.N. 2005. Effects of sound on fish. Technical report for Jones and Stokes to California Department of Transportation, Sacramento, CA.

Johnson, C.S., M.W. McManus, and D. Skaar. 1989. Masked tonal hearing thresholds in the beluga whale. Journal of the Acoustical Society of America 85:2651–54.

Jones, M.L. and S.L. Swartz. 1984. Demography and phenology of gray whales and evaluation of whale-watching activities in Laguna San Ignacio, Baja California Sur, Mexico. p. 309-374 In: M. L. Jones et al. (eds.), The Gray Whale *Eschrichtius robustus*. Academic Press, Orlando, FL. 600 p.

Jonsgård, Å. 1966a. Biology of the North Atlantic fin whale *Belaenoptera physalus* (L.). Taxonomy, distribution, migration and food. Hvalrådets Skrifter 49:1-62.

Kastak, D., B.L. Southall, R.J. Schusterman and C. Reichmuth Kastak. 2005. Underwater temporary threshold shift in pinnipeds: effects of noise level and duration. J. Acoust. Soc. Am. 118(5):3154-3163

Kastelein, R.A., S. van der Heul, W. Verboom, R. Triesscheijn, and N. Jennings. 2006. The influence of underwater data transmission sounds on the displacement behavior of captive harbor seals (*Phoca vitulina*). Marine Environmental Research, 61, 19-39.

Kelly, B. P. 1988a. Ringed seal, *Phoca hispida*. Pp. 57-75 In J. W. Lentfer (ed.), Selected marine mammals of Alaska. Species accounts with research and management recommendations. Marine Mammal Commission, Washington, D.C.

Kelly, B.P. 1988b. Bearded seal, *Erignathus barbatus*. p. 77-94 In: J.W. Lentfer (ed.), Selected Marine Mammals of Alaska/Species Accounts with Research and Management Recommendations. Mar. Mamm. Comm., Washington, DC. 275 p.

Kelly, B. P., J. L. Bengtson, P. L. Boveng, M. F. Cameron, S. P. Dahle, J. K. Jansen, E. A. Logerwell, J. E. Overland, C. L. Sabine, G. T. Waring, and J. M. Wilder. 2010. Status review of the ringed seal (*Phoca hispida*). U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-212, 250 p.

Ketten, D.R. 1994. Functional analysis of whale ears: adaptations for underwater hearing. IEEE Proc. Underwater Acoustics 1:264-270.

King, J.E. 1983. Seals of the World, 2nd ed. Cornell Univ. Press, Ithaca, NY. 240 p.

Konsberg. 2014. Dual-frequency side scan sonar. Technical Brochure-analog dual frequency side scan sonar.http://www.km.kongsberg.com/ks/web/nokbg0397.nsf/AllWeb/2832A199EEBD3EE9C125 74BF0050D4E0/$file/GeoAcoustics-DFSS-data-sheet.pdf?OpenElement.

Koski, W.R., Thomas, T.A., G.W. Miller, R.A. Davis, and W.J. Richardson. 2002. Residence times and rates of movement of bowhead whales in the Beaufort Sea and Amundsen Gulf during summer and autumn. Chapter 11. In: W.J. Richardson and D.H. Thomson (eds). Bowhead whale feeding in the eastern Alaskan Beaufort Sea: Final Report. Report by LGL Ltd., King City, for Minerals Management Service, Anchorage, AK.

Koski, W.R., J. Zeh, J. Mocklin, A.R. Davis, D.J. Rugh, J.C. George, and R. Suydam. 2010. Abundance of Bering-Chukchi-Beaufort bowhead whales (*Balaena mystecetus*) in 2004 estimated from photo-identification data. J. Cetac. Res. Manage. 11(2): 89-99.

Kryter, K.D. 1985. The effects of noise on man, 2nd ed. Academic Press, Orlando, FL. 688 p.

Kryter, K.D. 1994. The handbook of hearing and the effects of noise. Academic Press, Orlando, FL. 673pp.

Kunnasranta, M. 2001. Behavioural biology of two ringed seal (*Phoca hispida*) subspecies in the large European lakes Saimaa and Ladoga. Ph.D. Thesis. University of Joensuu, Joensuu, Finland. 86 p.

Laake, J., A. Punt., R. Hobbs, M. Ferguson, D. Rugh, and J. Breiwick. 2009. Re-analysis of gray whale southbound migration surveys 1967-2006. U.S. Dep. Commer. NOAA Tech. Memo. NMFS-AFSC-2003, 55p.

Landino, S.W., S.D. Treacy, S.A. Zerwick, and J.B. Dunlap. 1994. A Large aggregation of bowhead whales (*Balaena mysticetus*) feeding near Barrow, Alaska, in late Oct. 1992. Arctic 47(3):232-235.

Leatherwood, S., R. R. Reeves, W. F. Perrin, and W. E. Evans. 1982. Whales, dolphins, and porpoises of the eastern North Pacific and adjacent Arctic waters: A guide to their identification. U.S. Dep. Commer., NOAA Tech. Rept. NMFS Circular 444. 245 pp.

LGL and Greeneridge. 1996. Northstar Marine Mammal Monitoring Program, 1995: Baseline surveys and retrospective analyses of marine mammal and ambient noise data from the Central Alaskan Beaufort Sea. Rep. from LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, for BP Explor. (Alaska) Inc., Anchorage, AK. 104 p.

LGL and Greenridge (LGL Ltd. & Greeneridge Sciences). 1986. Reactions of beluga whales and narwhals to ship traffic and icebreaking along ice edges in the eastern Canadian High Arctic: 1982-1984. In Environmental studies (No. 37). Ottawa, ON, Canada: Indian and Northern Affairs Canada. 301 pp.

LGL Alaska Research Associates, Inc., JASCO Applied Sciences, Inc., and Greeneridge Sciences, Inc. 2014. Joint Monitoring Program in the Chukchi and Beaufort Seas, 2012. LGL Alaska Final Report P1272-2 for Shell Offshore, Inc. ION Geophysical, Inc., and Other Industry Contributors, National Marine Fisheries Service, and U.S. Fish and Wildlife Service. 320 p. plus Appendices.

LGL Alaska Research Associates, Inc. and JASCO Applied Sciences, Inc. 2014. Ice seal monitoring. (Chapter 8) In: LGL Alaska Research Associates, Inc., JASCO Applied Sciences, Inc., and Greeneridge Sciences, Inc. 2014. Joint Monitoring Program in the Chukchi and Beaufort Seas, 2012. LGL Alaska Final Report P1272-2 for Shell Offshore, Inc. ION Geophysical, Inc., and Other

Industry Contributors, National Marine Fisheries Service, and U.S. Fish and Wildlife Service. 320 p. plus Appendices.

Ljungblad, D.K., S.E. Moore, and J.T. Clarke. 1986. Assessment of bowhead whale (*Balaena mysticetus*) feeding patterns in the Alaskan Beaufort and northeastern Chukchi seas via aerial surveys, fall 1979-84. Rep. Int. Whal. Comm. 36:265-272.

Lowry, L.F., R.R. Nelson, and K.J. Frost. 1987. Observations of killer whales (*Orcincus orca*) in western Alaska: sightings, strandings and predation on other marine mammals. Canadian Field-Naturalist 101:6–12.

Lowry L.F. 1993. Foods and Feeding Ecology. In: Burns J.J., J.J. Montague, C.J. Cowles (eds.). The bowhead whale. Special Publication No. 2 Society for Marine Mammalogy, Lawrence, KS, PP 201-238.

Lowry, L.F., K.J. Frost, R. Davis, D.P. DeMaster, and R.S. Suydam. 1998. Movements and behavior of satellite-tagged spotted seals (*Phoca largha*) in the Bering and Chukchi Seas. Polar Biol. 19(4):221-230.

Lowry, L., and K. Frost. 2002. Beluga whale surveys in the eastern Chukchi Sea, July 2002. Alaska Beluga Whale Committee Rep. 02-2 submitted to NMFS, Juneau, AK. 10 pp.

Lowry, L.F., G. Sheffield, and J.C. George. 2004. Bowhead whale feeding in the Alaskan Beaufort Sea based on stomach contents analyses. J. Cetacean Res. Manage. 63: 223.

Lowry, L. F., K. J. Frost, A. Zerbini, D. DeMaster, and R. R. Reeves. 2008. Trend in aerial counts of beluga whales (*Delphinapterus leucas*) in Bristol Bay, Alaska, 1993-2005.

Lukin, L. P., G. N. Ognetov, and N. S. Boiko. 2006. Ecology of the ringed seal in the White Sea. UrO RAN, Ekaterinburg, Russia. 165 p. (Translated from Russian by the Baltic Fund for Nature (BFN), State University of St. Petersburg, Russia).

Lydersen, C. and M.O. Hammill. 1993. Diving in ringed seal (*Phoca hispida*) pups during the nursing period. Can. J. Zool. 71(5):991-996.

Lyons, C., W.R. Koski, and D.S. Ireland. 2009. Beaufort Sea aerial marine mammal monitoring program. (Chapter 7) In: Ireland, D.S., D.W. Funk, R. Rodrigues, and W.R. Koski (eds.). Joint monitoring program in the Chukchi and Beaufort seas, open water seasons, 2006–2007. LGL Alaska Report P971-2. Report from LGL Alaska Research Associates, Inc., Anchorage, AK, LGL Ltd., environmental research associates, King City, Ont., JASCO Research Ltd., Victoria, B.C., and Greeneridge Sciences, Inc., Santa Barbara, CA, for Shell Offshore, Inc., Anchorage AK, ConocoPhillips Alaska, Inc., Anchorage, AK, and the National Marine Fisheries Service, Silver Springs, MD, and the U.S. Fish and Wildlife Service, Anchorage, AK. 485 p. plus Appendices.

MacDonnell, J., C. O'Neill, R. Bohan, and D. Hannay. 2008. Underwater sound level measurements of airgun sources and support vessels from the Shell 2008 MV Gilavar survey at Chukchi Sea site A. Unpublished report prepared by JASCO Research Ltd., Victoria, BC.

Malme, C.I., P.R. Miles, C.W. Clark, P. Tyack, and J.E. Bird. 1983. Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior (BBN

Report No. 5366; NTIS PB86-174174). Report from Bolt Beranek and Newman Inc. for U.S. Minerals Management Service, Anchorage, AK.

Malme, C.I., P.R. Miles, C.W. Clark, P. Tyack, and J.E. Bird. 1984. Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior. Phase II: January 1984 migration (BBN Report No. 5586; NTIS PB86-218377). Report from Bolt Beranek and Newman Inc. for U.S. Minerals Management Service, Anchorage, AK.

Mate, B.R., G.K. Krutzikowski, and M.H. Winsor. 2000. Satellite-monitored movements of radio-tagged bowhead whales in the Beaufort and Chukchi seas during the late-summer feeding season and fall migration. Can. J. Zool. 78:1168-1181.

McFarland, S., L. Aerts, and S. Wisdom. 2015. Assessing disturbance responses of Pacific walruses (*Odobenus rosmarus divergens*) to vessel presence in the Chukchi Sea. Oral presentation at the Society of Marine Mammalogy Conference, San Francisco, CA. December 14-18, 2015.

Mitchell, E.D. 1975. Report on the meeting on small cetaceans, Montreal, April 1-11, 1974. J. Fish. Res. Board Can. 32:914-91.

Mizroch, S. A. 1992. Distribution of minke whales in the North Pacific based on sightings and catch data. Unpubl. doc. submitted to the Int. Whal. Comm. (SC/43/Mi36). 37 pp.

MMS. 2008. Beaufort Sea and Chukchi Sera planning areas: oil and gas lease sales 209, 212, 217, and 221: Draft Environmental Impact Statement. OCS EIS/EA MMS 2008-0055, Alaska OCS Region, Minerals Management Service, Anchorage, Alaska.

Moore, S.E. and R.R. Reeves. 1993. Distribution and movement. p. 313-386 In: J.J. Burns, J.J. Montague and C.J. Cowles (eds.), The Bowhead Whale. Spec. Publ. 2. Soc. Mar. Mammal., Lawrence, KS. 787 p.

Moore, S.E., J.C. George, K.O. Coyle, and T.J. Weingartner. 1995. Bowhead whales along the Chukotka coast in autumn. Arctic 48(2):155-160.

Moore, S.E., D.P. DeMaster, and P.K. Dayton. 2000. Cetacean habitat selection in the Alaskan Arctic during summer and autumn. Arctic 53(4):432-447.

Moore, S. E., J. M. Waite, N. A. Friday, and T. Honkalehto. 2002. Distribution and comparative estimates of cetacean abundance on the central and south-eastern Bering Sea shelf with observations on bathymetric and prey associations. Progr. Oceanogr. 55(1-2): 249-262.

Moore, S.E., J.M. Grebmeier and J.R. Davies. 2003. Gray whale distribution relative to forage habitat in the northern Bering Sea: current conditions and retrospective summary. Can. J. Zool. 81(4):734-742.

Moreland, E., M. Cameron, and P. Boveng. 2013. Bering Okhotsk Seal Surveys (BOSS), joint U.S.-Russian aerial surveys for ice-associated seals, 2012-13. Alaska Fisheries Science Center Quarterly Report July-August-September 2013:1-6.

Morisaka, T., M. Shinohara, F. Nakahara, and T. Akamatsu. 2005. Effects of ambient noise on the whistles of Indo-Pacific bottlenose dolphin populations. Journal of Mammalogy, 86, 541-546.

Morton, A.B., and H.K. Symonds. 2002. Displacement of Orcinus orca (Linnaeus) by high amplitude sound in British Columbia, Canada. ICES Journal of Marine Science, 59, 71-80.

Moulton, V.D. and G.W. Miller. 2005. Marine mammal monitoring of a seismic survey on the Scotian Slope, 2003. p. 29-40 in K. Lee, H. Bain and G.V. Hurley, eds. 2005. Acoustic Monitoring and Marine Mammal Surveys in The Gully and Outer Scotian Shelf before and during Active Seismic Programs. Environmental Studies Research Funds Report. No. 151. 154 p.

Nerini, M. 1984. A review of gray whale feeding ecology. p. 423-450 In: M.L. Jones, S.L. Swartz and S. Leatherwood (eds.), The Gray Whale, *Eschrichtius robustus*. Academic Press, Inc. Orlando, FL. 600 p.

NMFS. 2000. Small takes of marine mammals incidental to specified activities; marine seismic-reflection data collection in southern California/Notice of receipt of application. Fed. Regist. 65(60, 28 Mar.):16374-16379.

NMFS. 2005. Assessment of acoustic exposures on marine mammals in conjunction with USS Shoup active sonar transmissions in Haro Strait, Washington, 5 May 2003 (NMFS Office of Protected Resources report).

NMFS. 2012a. Endangered and threatened species; threatened status for the Beringia and Okhotsk distinct population segments of the *Erignathus barbatus nauticus* subspecies of the bearded seal. Fed. Regist. 77(249, 18 Dec.):76740-76768.

NMFS. 2012b. Endangered and threatened species; threatened status for the Arctic, Okhotsk, and Baltic subspecies of the ringed seal and Endangered Status for the Ladoga subspecies of the ringed seal. Fed. Regist. 77(249, 28 Dec.):76706-76738.

NMFS. 2015. DRAFT Guidance for Assessing the Effects of Anthropoenic Sounds ON amrien Mammal Hearing. Underwater acoustic threshold levels for onset of permantent and termporary threshold shifts. Revised version for second public comment period. July 23, 2015. http://www.nmfs.noaa.gov/pr/acoustics/guidelines.htm.

NOAA. 2010. CHAOZ (Chukchi Acoustic, Oceanographic, and Zooplankton) Study: 2010 Cruise Report. National Marine Mammal Laboratory, Alaska Fisheries Science Center, and the Pacific Marine Environmental Laboratory.

NOAA. 2011. CHAOZ (Chukchi Acoustic, Oceanographic, and Zooplankton) Study: 2010 Cruise Report. National Marine Mammal Laboratory, Alaska Fisheries Science Center, and the Pacific Marine Environmental Laboratory.

Nowacek, D.P., M. Johnson, and P. Tyack. 2004. North Atlantic right whales (*Eubalaena glacialis*) ignore ships but respond to alerting stimuli. Proceedings of the Royal Society of London Series B: Biological Sciences, 271, 227-231.

O'Corry-Crowe, G.M., R.S. Suydam, A. Rosenberg, K.J. Frost, and A.E. Dizon. 1997. Phylogeography, population structure and dispersal patterns of the beluga whale *Delphinapterus leucas* in the western Nearctic revealed by mitochondrial DNA. Molec. Ecol. 6(10):955-970.

O'Neill, C. and A. McCrodan. 2012a. Vessel Sound Source Characterization Measurements at Burger Prospect Preliminary Report. Version 1.0, September 14, 2012. Technical report prepared by JASCO Applied Sciences for Shell Exploration Co. 17 pp.

O'Neill, C. and A. McCrodan. 2012b. Vessel Sound Source Characterization Measurements at Burger Prospect Preliminary Report Part 2. Version 1.0, October 5, 2012. Technical report prepared by JASCO Applied Sciences for Shell Exploration Co. 8 pp.

Orenstein, S., L. Langstaff, L. Manning, and R. Maund. 2004. Advisory Committee on Acoustic Impacts on Marine Mammals. Sponsored by the Marine Mammal Commission. Second Meeting, April 28-30, 2004. Arlington, Virginia . Final Meeting Summary. August 10.

Owl Ridge Natural Resource Consultants. 2013. Application for the Incidental Harassment Authorization for the Taking of Whales and Seals in Conjunction with the SAAE Proposed 3D Seismic Survey in the Beaufort Seal, Alaska, Summer 2013. March, 2013. 56 pages.

Philo, M, J. George, R. Suydam, T. Albert, and D. Ramey. 1994. Report of field activities of the spring 1992 census of bowhead whales, *Balaena mysticetus*, off Point Barrow, Alaska, with observations on the subsistence hunt of bowhead whales 1991 and 1992. Int. Whal. Comm. Paper SC/45/AS2. Cambridge, UK.

Popper AN, Carlson TJ. 1998. Application of sound and other stimuli to control fish behavior. Trans Am Fish Soc 127:673–707.

Quakenbush, L.T. 1988. Spotted seal, *Phoca largha*. p. 107-124 In: J.W. Lentfer (ed.), Selected Marine Mammals of Alaska/Species Accounts with Research and Management Recommendations. Marine Mammal Comm., Washington, DC. 275 p.

Quakenbush, L., J.J. Citta, J.C. George, R. Small, and M.P. Heide-Jorgensen. 2009. Fall Movement of Bowhead Whales in the Chukchi Sea. Marine Science in Alaska: 2009 Symposium. www.alaskamarinescience.org.

Quakenbush, L., J.J. Citta, J.C. George, R. Small, and M.P. Heide-Jorgensen. 2010a. Fall and winter movements of bowhead whales (*Balaena mysticetus*) in the Chukchi Sea and within a potential petroleum development area. Arctic. 63(3):289-307.

Quakenbush, L.T., R.J. Small, and J.J. Citta. 2010b. Satellite tracking of Western Arctic bowhead whales. Unpubl. report submitted to the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE 2010-033).

Quakenbush, L.T., R.J. Small, and J.J. Citta. 2013. Satellite tracking of bowhead whales: movements and analysis from 2006 to 2012. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Alaska Outer Continental Shelf Region, Anchorage, AK. OCS Study BOEM 2013-01110. 60 pp + appendices.

Read, A.J. 1999. Harbour porpoise Phocoena phocoena (Linnaeus, 1758). p. 323-355 In: S.H. Ridgway and R. Harrison (eds.), Handbook of Marine Mammals. Vol. 6: The Second Book of Dolphins and the Porpoises. Academic Press, San Diego, CA. 486 p.

Reeves, R.R., B.S. Stewart, P.J. Clapham and J.A. Powell. 2002. Guide to Marine Mammals of the World. Chanticleer Press, New York, NY.

Reider, H.J., L.N. Bisson, K.B. Matthews, and C.M. Reiser. 2013. Marine mammal monitoring results during shallow hazards and ice gouge surveys. (Chapter 5) In: Reider, H.J., L.N. Bisson, M. Austin, A. McCrodan. J. Wladichuk, C.M. Reiser, K.B. Matthews, J.R. Brandon, K. Leonard, and H.M. Patterson. 2013. Marine mammal monitoring and mitigation during Shell's activities in the Chukchi Sea, July–September 2013: Draft 90-Day Report. LGL Report P1272D–2. Report from LGL Alaska Research Associates Inc., Anchorage, AK, USA, and JASCO Applied Sciences, Victoria, BC, Canada, for Shell Gulf of Mexico, Houston, TX, USA, National Marine Fisheries Service, Silver Spring, MD, USA, and U.S. Fish and Wildlife Service, Anchorage, AK, USA. 198 pp, plus appendices.

Reiser, C., B. Haley, D. Savarese, and D.S. Ireland. 2009a. Chukchi Sea vessel-based monitoring program. (Chapter 3) In: Ireland, D.S., D.W. Funk, R. Rodrigues, and W.R. Koski (eds.). Joint monitoring program in the Chukchi and Beaufort seas, open water seasons, 2006–2007. LGL Alaska Report P971-2. Report from LGL Alaska Research Associates, Inc., Anchorage, AK, LGL Ltd., environmental research associates, King City, Ont., JASCO Research Ltd., Victoria, B.C., and Greeneridge Sciences, Inc., Santa Barbara, CA, for Shell Offshore, Inc., Anchorage AK, ConocoPhillips Alaska, Inc., Anchorage, AK, and the National Marine Fisheries Service, Silver Springs, MD, and the U.S. Fish and Wildlife Service, Anchorage, AK. 485 p. plus Appendices.

Reiser, C.M., B. Haley, J. Beland, D.M. Savarese, D.S. Ireland, and D.W. Funk. 2009b. Evidence for short-range movements by phocid species in reaction to marine seismic surveys in the Alaskan Chukchi and Beaufort Seas. Poster presented at: 18th Biennial Conference on the Biology of Marine Mammals, 12–16 October 2009, Quebec City, Canada.

Reiser, C.M, D.W. Funk, R. Rodrigues, and D. Hannay. (eds.) 2011. Marine mammal monitoring and mitigation during marine geophysical surveys by Shell Offshore, Inc. in the Alaskan Chukchi and Beaufort seas, July–October 2010: 90-day report. LGL Rep. P1171E–1. Rep. from LGL Alaska Research Associates Inc., Anchorage, AK, and JASCO Applied Sciences, Victoria, BC for Shell Offshore Inc, Houston, TX, Nat. Mar. Fish. Serv., Silver Spring, MD, and U.S. Fish and Wild. Serv., Anchorage, AK. 240 pp, plus appendices.

Rice, D.W. and A.A. Wolman. 1971. The life history and ecology of the gray whale (*Eschrichtius robustus*). Am. Soc. Mamm. Spec. Publ. 3:142 p.

Richard P. R., A. R. Martin, and J. R. Orr. 2001. Summer and autumn movements of belugas of the eastern Beaufort Sea stock. Arctic 54: 223-236.

Richardson, W., C. Greene, W. Koski, M. Smultea, C. Holdsworth, G. Miller, T. Woodley, and B. Wursig. 1991. Acoustic effects of oil production activities on bowhead and white whales visible during spring migration near Pt. Barrow, Alaska - 1990 Phase. OCS Study MMS 91-0037, USDOI Minerals Management Service, Herndon, VA 311 pp.

Richardson, W.J., C.R. Greene, Jr., J.S. Hanna,. W.R. Koski, G.W. Miller, N.J. Patenaude, and M.A. Smultea. 1995a. Acoustic effects of oil production activities on bowhead and white whales visible during spring migration near Pt. Barrow, Alaska—1991 and 1994 phases: sound propagation and whale responses to playbacks of icebreaker noise. OCS Study MMS 95-0051.

Richardson, W.J., C.R. Greene, Jr., C.I. Malme and D.H. Thomson. 1995b. Marine Mammals and Noise. Academic Press, San Diego. 576 p.

Richardson, W.J., M.A. Fraker, B. Wursig, and R.S. Wells. 1985a. Behavior of bowhead whales, *Balaena mysticetus,* summering in the Beaufort Sea: reactions to industrial activities. Biological Conservation 32(3):195-230.

Richardson, W.J., R.S. Wells, and B. Wursig. 1985b. Disturbance responses of Bowheads, 1980-1984. p. 255-306 in: W.J. Richardson, editor. Behavior, disturbance responses, and distribution of bowhead whales, *Balaena mysticetus* in the Eastern Beaufort Sea, 1980-84. OCS Study MMS 85-0034 USDOI, Minerals Management Services, Alaska OCS Region, Anchorage, AK.

Richardson, W.J., D.B. Fissel, J.R. Marko, J.R. Birch, G.A. Borstad, D.N Truax, R. Kerr, W.B. Griffiths, D.H. Thomson, B. Wursig, G.W. Miller, D.M. Schell, S.M. Saupe, N. Haubenstock, J. Goodyear, and D.R. Schmidt. 1987. Importance of the Eastern Alaskan Beaufort Sea to Feeding Bowhead Whales, 1985-1986. OCS Study MMS 87-0037, Contract no. 14-12-0001-30233. Prepared for the U.S. Department of the Interior Minerals Management Service by LGL, Ltd., Arctic Sciences Ltd., BioSonics, Inc., G.A. Borstad Associates Ltd., and University of Alaska, Fairbanks. Bryan: LGL, Ltd.

Richardson, W.J., T.L. McDonald, C.R. Greene, Jr., and S.B. Blackwell. 2008. Effects of Northstar on distribution of calling bowhead whales 2001-2004. Chapter 10 In: Richardson, W.J. (ed.). 2008. Monitoring of industrial sounds, seals, and bowhead whale calls near BP's Northstar Oil Development, Alaskan Beaufort Sea, 1999-2004. Comprehensive Report, 3rd Update, Feb. 2008. LGL Rep. P1004. Rep. from LGL Ltd. (King city, Ont.), Greeneridge Sciences, Inc. (Santa Barbara, CA), WEST, Inc., (Cheyene, WY), and Applied Sociocultural Research (Anchorage, AK), for BP Explor. (Alaska) Inc., (Anchorage, AK).

Ridgway, S. H., D.A. Carder, T. Kamolnick, R.R. Smith, C.E. Schlundt, and W.R. Elsberry. 2001. Hearing and whistling in the deep sea: Depth influences whistle spectra but does not attenuate hearing by white whales (*Delphinapterus leucas*) (Odontoceti, Cetacea). Journal of Experimental Biology 204:3829-3841.

Rugh, D.J., K.E.W. Shelden and D.E. Withrow. 1997. Spotted seals, *Phoca largha*, in Alaska. Mar. Fish. Rev. 59(1):1-18.

Rugh, D., D. DeMaster, A. Rooney, J. Breiwick, K. Shelden, and S. Moore. 2003. A review of bowhead whale (*Balaena mysticetus*) stock identity. Journal of Cetacean Research and Management 5(3): 267-279.

Rugh, D.J., R.C. Hobbs, J.A. Lerczak and J.M. Breiwick. 2005. Estimates of abundance of the eastern North Pacific stock of gray whales (*Eschrichtius robustus*) 1997-2002. J. Cetac. Res. Manage. 7(1):1-12.

Rugh, D., J. Breiwich, M. Muto, R. Hobbs, K. Sheldon, C. D'Vincent, I.M. Laursen, S. Reif, S. Maher and S. Nilson. 2008. Report of the 2006-7 census of the eastern North Pacific stock of gray whales. AFSC Processed Rep. 2008-03, 157 p. Alaska.

Scheifele, P.M., S. Andrews, R.A. Cooper, M. Darre, F.E. Musick, and L. Max. 2005. Indication of a Lombard vocal response in the St. Lawrence River beluga. Journal of the Acoustical Society of America, 117, 1486-1492.

Schick and Urban. 2000. Spatial components of bowhead whale (*Balaena mysticetes*) distribution in the Alaskan Beaufort Sea. Can. J. Fish. Aquat. Sci. 57:2193-2200.

Seaman, G. A., K. J. Frost, and L. F. Lowry. 1985. Investigations of belukha whales in coastal waters of western and northern Alaska. Part I. Distribution, abundance and movements. U.S. Dep. Commer., NOAA, OCSEAP Final Rep. 56:153-220. Available from NOAA-OMA-OAD, Alaska Office, 701 C. Street, P.O. Box 56, Anchorage, AK 99513.

Sergeant, D. E., and P. F. Brodie. 1969. Body size in white whales, Delphinapterus leucas. J. Fish. Res. Bd. Can. 26:2561-2580.

Shaughnessy, P.D. and F.H. Fay. 1977. A review of the taxonomy and nomenclature of North Pacific harbor seals. J. Zool. (Lond.) 182:385-419.

Shell Gulf of Mexico Inc. (Shell). 2015. Application for Incidental Harassment Authorization for the Non-Lethal Taking of Whales and Seals in Conjunction with Planned Exploration Drilling Activities During 2015. Chukchi Sea, Alaska. Revised February, 2015. 140 pages.

Small, R. J., and D. P. DeMaster. 1995. Alaska marine mammal stock assessments 1995. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-57, 93 pp.

Smith, T.G. 1973. Population dynamics of the ringed seal in the Canadian eastern arctic. Fish. Res. Board Can. Bull. 181:55 p.

Smith, T.G. and I. Stirling. 1975. The breeding habitat of the ringed seal (*Phoca hispida*): the birth lair and associated structures. Can. J. Zool. 53(9):1297-1305.

Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene Jr., D. Kastak, D.K. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas, and P.L. Tyack. 2007. Marine mammal noise exposure criteria: initial scientific recommendations. Special Issue of Aquatic Mammals, 33(4): 412-522.

Stirling, I., M. Kingsley and W. Calvert. 1982. The distribution and abundance of seals in the eastern Beaufort Sea, 1974-79. Can. Wildl. Serv. Occas. Pap. 47:25 p.

Stone, C.J. and M.L. Tasker. 2006. The effects of seismic airguns on cetaceans in UK waters. J. Cetac. Res. Manage. 8(3):255-263.

Suydam, R.S. and J.C. George. 1992. Recent sightings of harbor porpoises, *Phocoena phocoena*, near Point Barrow, Alaska. Can. Field-Nat. 106(4): 489-492.

Suydam, R.S., J.C. George, P.B. Nader, and T.F. Albert. 1995a. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos, 1994. Int. Whal. Comm. Paper SC/47/AS12. Cambridge, UK.

Suydam, R.S., R.P. Angliss, J.C. George, S.R. Braund, and D.P. DeMaster. 1995b. Revised data on the subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaska Eskimos, 1973-1993. Rep. Int. Whal. Comm. 45:335-338.

Suydam, R.S., J.C. George, T.M. O'Hara, and T.F. Albert. 1996. Efficiency of the subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaska Eskimos, 1973 to 1995, and observations on the 1995 subsistence harvest, paper SC/48/AS14 submitted to the Scientific Committee of the International Whaling Commission, June, 1996.

Suydam, R.S., J.C. George, T.M. O'Hara, and T.F. Albert. 1997. Efficiency of the subsistence harvest of bowhead whales by Alaskan Eskimos, 1973 to 1996 with observations on the 1995, 1996, and 1997 subsistence harvests. Int. Whal. Comm. Paper SC/49/AS21. Cambridge, UK.

Suydam, R. S., L. F. Lowry, K. J. Frost, G. M. O'Corry-Crowe, and D. Pikok, Jr. 2001a. Satellite tracking of eastern Chukchi Sea beluga whales into the Arctic Ocean. Arctic 54(3):237-243.

Suydam, R.S., L.F. Lowry, K.J. Frost, G.M. O'Corry-Crowe, and D. Pikok Jr. 2001b. Satellite tracking of eastern Chukchi Sea beluga whales into the Arctic Ocean. Arctic 54(3):237-243.

Suydam, R.S., T.M. O'Hara , J.C. George, V.M. Woshner, and G. Sheffield. 2002. Subsistence harvest of bowhead whales by Alaska Eskimos during 2001. Int. Whal. Comm. Paper SC/54/BRG20. Cambridge, UK.

Suydam, R.S., J.C. George, T.M. O'Hara, and G. Sheffield. 2003. Subsistence harvest of bowhead whales by Alaska Eskimos during 2002. Int. Whal. Comm. Paper SC/55/BRG5. Cambridge, UK.

Suydam, R.S., J.C. George, T.M. O'Hara, C. Hanns, and G. Sheffield. 2004. Subsistence harvest of bowhead whales (*Balaenus mysticetus*) by Alaskan Eskimos during 2003. Int. Whal. Comm. Paper SC/56/BRG11. Cambridge, UK.

Suydam, R.S., J.C. George, T.M. O'Hara, C. Hanns, and G. Sheffield. 2005. Subsistence harvest of bowhead whales (*Balaenus mysticetus*) by Alaskan Eskimos during 2004. Int. Whal. Comm. Paper SC/57/BRG15. Cambridge, UK.

Suydam, R. S., L. F. Lowry, and K. J. Frost. 2005. Distribution and movements of beluga whales from the eastern Chukchi Sea stock during summer and early autumn. OCS Study MMS 2005-035 Final Report. 48 pp.

Suydam, R.S., J.C. George, C. Hanns, and G. Sheffield. 2006. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2005. Int. Whal. Comm. Paper SC/58/BRG21. Cambridge, UK.

Suydam, R.S., J.C. George, C. Rosa, B. Person, C. Hanns, G. Sheffield, and J. Bacon. 2007. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2006. Int. Whal. Comm. Paper SC/59/BRG4. Cambridge, UK.

Suydam, R.S., J.C. George, C. Rosa, B. Person, C. Hanns, G. Sheffield, and J. Bacon. 2008. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2007. Int. Whal. Comm. Paper SC/60/BRG10. Cambridge, UK.

Suydam, R.S., J.C. George, C. Rosa, B. Person, C. Hanns, G. Sheffield, and J. Bacon. 2009. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2008. Int. Whal. Comm. Paper SC/61/BRG6. Cambridge, UK.

Suydam, R.S., J.C. George, C. Rosa, B. Person, C. Hanns, and G. Sheffield. 2010. Subsistence harvest of bowhead whales (*Balaena mysticetus)* by Alaskan Eskimos during 2009. Int. Whal. Comm. Paper SC/62/BR18. Cambridge, UK.

Suydam, R.S., J.C. George, C. Rosa, B. Person, C. Hanns, and G. Sheffield. 2011. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2010. Paper SC/62/BRG2 submitted to the International Whaling Commission, Cambridge, UK.

Suydam, R.S., J.C. George, C. Rosa, B. Person, C. Hanns, and G. Sheffield. 2012. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2011. Paper SC/62/BR18 submitted to the International Whaling Commission, Cambridge, UK.

Suydam, R., J.C. George, B. Person, C. Hanns, R. Stimmelmayr, L. Pierce, and G. Sheffield. 2013. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2012. Paper SC/65a/BRG19 submitted to the International Whaling Commission, Cambridge, UK.

Swartz, S.L. and M.L. Jones. 1981. Demographic studies and habitat assessment of gray whales, *Eschrichtius robustus*, in Laguna San Ignacio, Baja California, Mexico. U.S. Mar. Mamm. Comm. Rep. MMC-78/03. 34 p. NTIS PB-289737.

Teledyne Benthos Geophysical. 2008. Sonar Imaging Systems, effective July, 2008. 2008 Geophysical Product Catalog. http://www.tritonimaginginc.com/site/content/software/compatibility/benthos_cd3lpm.pdf

Thewissen, J.G.M., J.D. Sensor, J.C. George, R.S. Suydam, and M.C. Liberman. 2011. Assessment of auditory trauma in the inner ear of Arctic whales. Abstracts of the 19th Biennial Conference on the Biology of Marine Mammals. November 27–December 2, 2011. Tampa, FL.

Thomas, T.A., W.R. Koski, and W. J. Richardson. 2002. Correction factors to calculate bowhead whale numbers from aerial surveys of the Beaufort Sea. In Richardson, W.J. and D.H. Thomson (eds.). 2002. Bowhead whale feeding in the eastern Alaskan Beaufort Sea: update of scientific and traditional information. OCS Study MMS 2002-012; LGL Rep. TA2196-7 Rep. from LGL Ltd. King City, Ont., for U.S. Minerals Manage. Serv., Anchorage, AK, an Herndon, VA. Vol. 1, xliv + 420 p; Vol. 2, 277p.

Thomas, T., W.R. Koski, and T. Elliot. 2009. Chukchi Sea nearshore aerial surveys. (Chapter 4) In: Ireland, D.S., D.W. Funk. R. Rodrigues, and W.R. Koski (eds.). 2009. Joint Monitoring Program in the Chukchi and Beaufort seas, open water seasons, 2006–2007. LGL Alaska Report P971–2, Report from LGL Alaska Research Associates, Inc., Anchorage, AK, LGL Ltd., environmental research associates, King City, Ont., JASCO Research, Ltd., Victoria, BC, and Greeneridge Sciences, Inc., Santa Barbara, CA, for Shell Offshore, Inc., Anchorage, AK, ConocoPhillips Alaska, Inc., Anchorage, AK, and the National Marine Fisheries Service, Silver Springs, MD, and the U.S. Fish and Wildlife Service, Anchorage, AK. 485 p. plus Appendices.

Thomas, T., and W.R. Koski. 2013. Chukchi Sea nearshore aerial surveys. (Chapter 4) In: Funk, D.W., C.M. Reiser, D.S. Ireland, R. Rodrigues, and W.R. Koski (eds.). 2013. Joint Monitoring Program in the Chukchi and Beaufort seas, 2006–2010. LGL Alaska Report P1213-2, Report from LGL Alaska Research Associates, Inc., LGL Ltd., Greeneridge Sciences, Inc., and JASCO Research, Ltd., for Shell Offshore, Inc. and Other Industry Contributors, and National Marine Fisheries Service, U.S. Fish and Wildlife Service. 592 p. plus Appendices.

Tomilin, A.G. 1957. Mammals of the U.S.S.R. and adjacent countries, Vol. 9: Cetaceans. Israel Progr. Sci. Transl. (1967), Jerusalem. 717 p. NTIS TT 65-50086.

Treacy, S.D. 1993. Aerial surveys of endangered whales in the Beaufort Sea, fall 1992. OCS Study MMS 93-0023. U.S. Minerals Manage. Serv., Anchorage, AK. 136 p.

Trukhin, A. M. 2000. Ringed seal on the eastern coast of Sakhalin Island. Page 4 in V. M. Belkovich, A. N. Boltunov, and I. V. J. Smelova, editors. Marine Mammals of the Holarctic. 2000. Materials from the International Conference, Archangel, Russia. Pravda Severa. (Translated from Russian by Olga Romanenko, 4 p.).

U.S. Department of Commerce (USDOC), National Oceanic and Atmospheric Administration (NOAA). 2015. DRAFT Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing. Underwater Acoustic Threshold Levels for Onset of Permanent and Temporary Threshold Shifts. Revised version for Second Public Comment Period. July 2015. 187 pages.

Ver Hoef, J. M., Cameron, M. F., Boveng, P. L., London, J. M., and Moreland, E. M. In Press. A hierarchical model for abundance of three ice-associated seal species in the Eastern Bering Sea. Statistical Methodology.

White, M.J., J. Norris, D.L. Jungblad, K. Baron, and G. Di Sciara. 1978. Auditory thresholds of two beluga whales (Delphinapterus leucas). HSWRI Technical Report 78-109. Prepared for Naval Ocean Systems Center, San Diego.

Wiese, K. 1996. Sensory Capacities of Euphausiids in the Context of Schooling. Mar Freshw Behav Physiol. 28:183–194.

Wong, C.K. 1996. Effects of diazinon on the demographic parameters of *Moina macrocopa*. Water, Air and Soil Pollution 393:393-399.

Würsig, B., W.R. Koski, T.A. Thomas, and W.J. Richardson. 2002. Activities and behavior of bowhead whales in the eastern Alaskan Beaufort Sea during late summer and autumn. Chapter 12. In: W.J. Richardson and D.H. Thomson (eds). Bowhead whale feeding in the eastern Alaskan Beaufort Sea: Final Report. Report by LGL Ltd., King City, for Minerals Management Service, Anchorage, AK.

Zeh, J.E., A.E. Raftery and A.A. Schaffner. 1996. Revised estimates of bowhead population size and rate of increase. Rep. Int. Whal. Comm. 46:670.

Zeh, J.E. and A.E. Punt. 2005. Updated 1978-2001 abundance estimates and their correlations for the Bering-Chukchi-Beaufort Seas stock of bowhead whales. J. Cetac. Res. Manage. 7(2):169-175.

APPENDIX A

MARINE MAMMAL MONITORING & MITIGATION PLAN

APPENDIX B

PLAN OF COOPERATION